Volume 4 MARCH, 1925 Number 3

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Published Monthly by the American Welding Society
33 West Thirty-ninth Street, New York

American Welding Society

OFFICERS FOR 1924-25

E. H. EWERTZ, *President*
C. A. MCCUNE, *Treasurer*
M. M. KELLY, *Secretary*
T. A. WRY, *Vice-President*
J. D. CONWAY, *Vice-President*
H. S. MANN, *Vice-President*
A. V. THOMPSON, *Vice-President*
C. L. JONES, *Vice-President*

DIRECTORS

(Officers listed above are also members of the Board of Directors)

Term Expires 1925	*Term Expires* 1926	*Term Expires* 1927	*Section Representatives*
JAMES BURKE	C. A. ADAMS	J. H. DEPPELER	A. G. OEHLER
A. F. JENKINS	A. M. CANDY	A. S. KINSEY	J. C. LINCOLN
J. W. OWENS	C. J. HOLSLAG	E. M. T. RYDER	R. D. REED
H. I. WALSH	H. S. SMITH	W. A. SLACK	H. D. KELLEY
S. W. MILLER	C. A. MCCUNE	T. F. BARTON	W. A. SLACK
			J. W. MORRISEY
			C. W. BATES
			G. W. SWAN

PAST-PRESIDENTS

C. A. ADAMS (1919-20)
J. H. DEPPELER (1920-21)
S. W. MILLER (1921-22)
C. A. MCCUNE (1922-23)
T. F. BARTON (1923-24)

CHAIRMEN, STANDING COMMITTEES

Executive—E. H. EWERTZ
Finance—C. A. MCCUNE
By-Laws—A. M. CANDY
Meetings and Papers—K. H. CONDIT
Membership—C. A. MCCUNE

W. SPRAGEN, *Editor, Journal*

American Bureau of Welding

(RESEARCH DEPARTMENT OF SOCIETY)

OFFICERS

C. A. ADAMS, *Director*
H. M. HOBART, *1st Vice-Director*
A. S. KINSEY, *2nd Vice-Director*
WM. SPRAGEN, *Secretary*

CHAIRMEN, RESEARCH COMMITTEES

Electric Arc Welding—H. M. HOBART
Gas Welding—S. W. MILLER
Welded Rail Joints—G. K. BURGESS
Welding Wire Specifications—C. A. MCCUNE
Resistance Welding—HERMANN LEMP
Thermit Welding—J. H. DEPPELER

Specifications for Iron and Steel to be Welded—W. J. BECK

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Copyright 1925, by the American Welding Society,
33 West Thirty-ninth Street, New York.

Subscription $10.00 per year to United States. $11.00 to Canada. Libraries $5.00.
Back numbers, per copy; Members, $0.50; Non members, $1.00.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication, provided proper credit is given.

Volume 4 **MARCH, 1925** **Number 3**

TABLE OF CONTENTS

Society and Related Activities **Page**

Program Annual Meeting 3
Pressure Vessels 5
Directory American Welding Society 5
Fifth Annual Meeting 6
Bound Volumes Journal 6
Technical Session 6
Arc Welding Bulletin 6
Section Activities 7
Employment Service Bulletin 8

Technical Papers, Items and Reports

Economies of High Purity Oxygen 10
Oxygen Purity Testing 21
Electric Power Supply to the Welding Industry 24
Application of Arc Welding to Manufacture and Repair Work 30
Welding Cast Iron with Bronze 36
Current Welding Literature 40

SECTION OFFICERS AND HEADQUARTERS

PHILADELPHIA

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

Chairman—Joseph W. Meadowcroft, E. G. Budd Mfg. Co.
Secretary—H. E. Hopkins, 709 W. Huntington St., Philadelphia, Pa.

CHICAGO

Monadnock Building, Chicago

Chairman—R. G. Mason, Atchison, Topeka & Santa Fe R. R. Co.
Secretary—Stuart Plumley, Editor, Acetylene Journal.

PITTSBURGH

1841 *Oliver Bldg., Pittsburgh*

Chairman—J. D. Conway, Secretary-Treasurer, Railway Supply Mfg. Assn.
Secretary—H. E. Hollis, P. O. Box 681, Pittsburgh, Pa.

NEW YORK

33 *West Thirty-ninth Street, New York*

Chairman—A. G. Oehler, Editor, *Railway Age.*
Secretary—A. F. Keogh, Sound Welding Company.

NORTHERN NEW YORK

General Electric Co., Schenectady

Chairman—D. H. Deyoe, General Electric Co., Schenectady, N. Y.
Secretary—V. J. Chapman, General Electric Co.

CLEVELAND

2200 *Chester Avenue, Cleveland, Ohio*

Chairman—Hugh H. Dyar, Linde Air Products Co.
Secretary—R. K. Randall, Dean, Welding School, Cleveland School of Technology.

SAN FRANCISCO

Rialto Building, San Francisco

Chairman—J. C. Bennett, Assistant Engineer, Associated Oil Co. of San Francisco.
Secretary—W. B. Sawyer, Jr., United States Steel Products Company.

LOS ANGELES

451 *East Third Street, Los Angeles*

Chairman—L. J. Smith, District Sales Manager, The Ideal Electric & Mfg. Co.
Secretary—E. W. Crane, E. E., 1119 Santa Fe Avenue, Los Angeles.

BOSTON

Engineers' Club, 2 Commonwealth Avenue, Boston, Mass.

Chairman—T. A. Wry, General Electric Co., Lynn, Mass.
Secretary—J. W. Morrissey, P. F. McDonald & Co.

WESTERN NEW YORK

509 *Morgan Bldg., Buffalo, N. Y.*

Chairman—G. W. Swan, J. A. Roebling's Sons Company.
Secretary—C. D. Miller, Burke Electric Co., Buffalo, N. Y.

DETROIT

Chairman—H. M. Gould, Assistant General Manager, Dept. of Street Railways, City of Detroit, Mich.
Secretary—C. L. Finch, Detroit Range Boiler and Steel Barrel Co., Detroit, Mich.

AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 4 March, 1925 Number 3

PROGRAM

ANNUAL MEETING
of the
AMERICAN WELDING SOCIETY
29 West 39th Street, New York, N. Y.
April 22, 23 and 24, 1925
All Sessions Start Promptly as Scheduled

WEDNESDAY, APRIL 22, 1925

Morning

Resistance Welding Committee, H. A. Woofter, Chairman
9:00 a. m. to 11, 10th floor.

Discussion of future plans of Committee. Work on the resistance welding of special metals.

Gas Welding Committee, S. W. Miller, Chairman
11:00 a. m. to 1 p. m., 10th floor.

Progress report on welding of manganese steel. Plans for future work of committee.

Afternoon

Electric Arc Welding Committee, H. M. Hobart, Chairman
2:00 p. m., 10th floor.

Progress report on investigation to determine certain fundamentals of electric arc welding such as effect of various currents, angles of bevel, number of layers of deposited metal, size of electrode, etc. A large number of test results will be analyzed at this meeting. Progress report of Sub-Committee on Arc Welding of Non-Ferrous Metals.

Evening

Educational Committee, American Welding Society, E. H. Ewertz, Chairman
7:30 p. m., 16th floor.

A meeting of Committee members will be held to discuss plans for the work of this Committee and ways and means for carrying out these plans.

THURSDAY, APRIL 23, 1925

Morning

Business Session of the American Welding Society
9:30 a. m. to 12, 5th floor.

Program

1. President's Report of Year's Activities.
2. Reports from (a) Finance Committee.
   (b) Meetings and Papers Committee.
   (c) Research Department (American Bureau of Welding).
   (d) Report of Tellers Committee on Election of Officers.
   (e) Introduction of New President.

Afternoon

1.45 p. m. Inspection trip. An inspection trip has been arranged through the Bayway Plant of the Standard Oil Company of New Jersey. A very interesting time is promised to all those who go on this inspection trip. Those who have seen this plant state that the inspection trip alone is worth the time and money to attend the sessions of the annual meeting. Details as to how to reach the plant will be announced later.

Evening

Fourth Annual Dinner of the American Welding Society
7:00 p. m.

Park Avenue Hotel, Park Avenue and Thirty-third Street, New York.

Tickets will be at the usual price of $5 per person. Those who attended last year know that good talent and plenty to eat will be enjoyed by everyone there. Reservations may be made at once by writing to the Secretary.

FRIDAY, APRIL 24, 1925

Morning

Technical Session of the American Welding Society
9:30 a. m. to 12; 12:45 to 2 p. m., 5th floor.

Symposium

1. Methods of Inspecting Welds.
2. Testing the skill of operators.

Some thirty experts in a wide variety of fields will give a summary of the practices employed in their industry on the above subject. It is hoped thru this symposium to secure authentic information as to the methods now employed in inspecting welds and testing the skill of operators for production work, general repair work, pressure vessel welding, pipe welding, tank welding, steel furniture, etc.

Note: A luncheon for members has been arranged at the Engineers Club. In order to save time, this luncheon will be served promptly at 12 o'clock and the technical session resumed at 12:45. Tickets may be obtained from the Secretary at $2 per person.

Afternoon

American Bureau of Welding Meeting

2:00 p. m. to 3:30 p. m.

Program

1. Progress report of research committee chairmen.
2. Election of officers.
3. Discussion of policies.
4. Appointment of new committees.

Board of Directors, American Welding Society (including retiring and new members)

3:30 to 6:00 p. m.

Program

1. Review of progress during past year.
2. Introduction of new President.
3. Appointment of Committees (a) Executive.
   (b) Membership.
   (c) Finance
   (d) Meetings and Papers.
   (e) Revision of By-Laws.
4. Plans for the coming year.

PRESSURE VESSELS

The American Bureau of Welding expects to shortly organize a new Pressure Vessel Committee. Since the publication of the report of the previous committee as Bulletin No. 5 of the American Welding Society, there has arisen the need for further information and investigational work in this field. As pointed out in a previous editorial, the present A. S. M. E. Code on the Welding of Unfired Pressure Vessels is unduly restrictive and incomplete in the eyes of the welding fraternity. The A. S. M. E. Boiler Code Committee have officially notified the Society that they are willing to cooperate with us at all times and will carefully consider any new data furnished by our Society.

The proposed Pressure Vessel Committee will therefore go over each rule of the code and where desirable suggest modifications. By agreement with the Boiler Code Committee of the A. S. M. E. these suggestions must always be accompanied by unbiased and carefully prepared scientific and engineering data. In many instances these data are not available and must be obtained as the result of additional tests. Where this is needed a program of the investigational work will be prepared by the Committee and the industry will be asked to contribute the necessary funds and materials. The testing work will probably be done as in the former instance at the Bureau of Standards.

DIRECTORY AMERICAN WELDING SOCIETY

The American Welding Society will in August publish a new directory. We are anxious to have it include as many members as possible. The only way that we can secure these new members is through the cooperation of our present membership. As an introduction to the directory, there is

printed a complete account of the activities of the Society and the value of membership in same. We will be glad to furnish every member with as many copies as he needs for distribution to prospective members of the American Welding Society. Please advise the Secretary at once how many copies you can distribute to advantage.

FIFTH ANNUAL MEETING

A tentative program of the fifth annual meeting is given elsewhere in this Journal. This meeting marks another milestone in the progress of the American Welding Society. We have grown considerably since our first meeting, although not quite as fast or as large as some of the loyal members and the Board of Directors have desired. We have, however, reached a standing in the technical world which we are all proud of. This recognition has come about largely through the accomplishments of our many committees, section activities and through our Journal.

The annual meeting serves not only as the time for taking inventory of our efforts and laying plans for the future but it also provides members of the Society an opportunity to get together to meet one another and to exchange ideas.

It is universally recognized that this opportunity of getting together and talking things over with the other fellow is one of the most important assets of conventions of any Society. Recognition of this fact has caused executives of leading companies to adopt the policy of sending several of their representatives. We are looking forward to a large attendance this year and are counting upon the support of every member. We already have assurance that a large number of guests from allied industries will attend our sessions to hear what we have to say. With your help we can do much to give welding another boost.

BOUND VOLUMES

Every year the American Welding Society binds a limited number of the Journals in permanent book form with an index of subjects and authors. These are sold to members at $5 per copy and form a permanent record of the Society's publication. The price to non-members is $10 per copy.

In the past a few of our members have taken advantage of this inexpensive means of having their Journals bound in book form. As a matter of fact, if one were to save the journals and bind them, the cost of binding to individual members would probably be as much as the price set by the Society. There are still available a few copies of the bound volumes for 1922 and 1923, as well as for 1924. Orders should be placed at once with the Secretary.

HELP WANTED

Through this editorial the Meetings and Papers Committee hope to enlist the aid of every member of the American Welding Society who is in a position to render such assistance.

The technical session of the annual meeting of the American Welding Society, to be held during the latter part of April, will be devoted to a symposium on two subjects, namely:

1. Methods and tests used by the various industries in testing and inspecting the welding work used in that industry, and
2. Testing and rating the skill of welding operators for different industries.

What is really wanted is a symposium on the various methods employed throughout the industrial world on these two subjects. If it is a production job, what inspecting is done to insure that the quality of the work is up to standard? Are there any tests made? Is the inspecting done during welding or after? Is the nature of the work such that the selection of conditions is determined in advance, thereby resulting in a uniform product? Are there any specifications or tests as to material?

In connection with the operators, are they required to pass examinations as to the quality of their output? Are tests made regularly on their work? Does the inspecting include the examination of the work of each operator? Are materials and design left to his selection or determined in advance?

You are requested to send in your discussion, even though it may occupy only two or three paragraphs on either or both of the above subjects.

APPLICATIONS OF ARC WELDING

Some time ago there was prepared for the American Bureau of Welding a complete treatise on the subject of "Application of Arc Welding to Ship

Construction." This was published as Bulletin No. 6 of the American Welding Society. Because of the tremendous cost of printing this bulletin, it was impossible to publish it in the Journal of the American Welding Society. As a special inducement for members to get a copy, the officers have set the price on the bulletin to members at fifty cents.

The bulletin should not only be of interest to people in the shipbuilding field, but in all places where the fabrication by welding can be considered. An enormous amount of test data, cost figures and design information is included. Because of the limited supply members are urged to take immediate advantage of this special offer.

SECTION ACTIVITIES

Boston:

The February meeting was held on the 27th at the Boston City Club. Mr. C. A. McCune, Treasurer and Vice-Chairman of the Society, gave an interesting address on the manufacture and inspection of various kinds of steel and iron wire. Mr. McCune illustrated by moving pictures the manufacture of various kinds of wires used in the suspension bridge from Philadelphia to Camden, showing the erection of the bridge and the various steps in the manufacture and inspection of material. Mr. McCune stressed the various steps necessary in wire drawing and manufacture of welding wire to insure a good product.

Western New York:

The February meeting of the Northern New York Section was held on the 18th at the Technical High School in Buffalo. Mr. J. H. Crowe, formerly of the Bureau of Standards and now head of the research department of the Air Reduction Sales Company, presented a lecture on "Oxygen the Wonder Worker." His remarks were illustrated by a new five reel film showing the manufacture of oxygen, magnified pictures of welding and cutting by oxy-acetylene and the action which takes place in the liquid pool during welding. Mr. Crowe also showed some lantern slides illustrating the greatly increased efficiency with comparative reduction in the cost by the use of increased purity of oxygen. Mr. Crowe then demonstrated by actual performance the testing of commercially pure oxygen. Some of the slides also showed the burning of holes in slag sculls with straight oxygen, these holes being for the insertion of dynamite cartridges for blasting the sculls.

New York:

The February meeting was held on the 16th. Mr. John J. Crowe of the Air Reduction Sales Company presented an illustrated paper on "Oxygen Purity Testing." He was followed by Mr. F. P. Gross, Jr., who illustrated methods used in oxygen testing.

The March meeting was held on the 10th at the Engineering Societies Building, at which time Mr. C. W. Bates, Assistant to the Chief Engineer of the Philadelphia Electric Company, presented a paper on the "Electric Power Supply to the Welding Industry." This paper aroused considerable discussion.

Cleveland:

The January meeting was held on the 27th at the headquarters of the Cleveland Engineering Society. A film prepared by the Union Carbide and Carbon Corporation on "Oxwelding and Cutting the Universal Tool for All Industries" was presented, as was also a reel and a half showing the bronze welding of some 6 in. cast iron pipe. The February meeting was held on the 17th at the Cleveland School of Technology and was devoted to the subject of pipe welding. A number of lantern slides were shown illustrating the arc welding of a steel pipe for carrying low pressure steam at one of the plants of the Carnegie Steel Company, Pittsburgh. The Thermit welding of steel pipe was next demonstrated by a representative of the Metal and Thermit Corporation at Pittsburgh. This was followed by a demonstration of bronze welding of 6 in. cast iron pipe by a representative of the Linde Air Products Company. Considerable discussion followed these demonstrations.

San Francisco:

The February meeting of the San Francisco Section was held on the 20th. Mr. Horace D. Jones, Chairman of the Committee having in charge the revision of the building code for the city of Oakland, discussed the status of welding as ap-

plied to building construction. The subject of unfired Pressure Vessels was also considered.

Chicago:

The March meeting of the Chicago Section was held on the 6th. A paper was presented by Mr. W. Bohnstengel, Assistant Engineer of Tests of the Atchison, Topeka and Santa Fe Railway System, dealing with the welding and cutting applications on this railroad. The list of officers elected at this meeting are as follows: Chairman, Thomas M. Jones, Illinois Steel Co.; Vice-Chairman, Jonathan Wolfe, Chicago Surface Lines; Secretary-Treasurer, Stuart Plumley, Acetylene Journal Publishing Co. Directors for three years: K. R. Hare, Transportation Engineering Corp'n; Donald B. McCloud, Associated with M. Keith Dunham; W. P. Roberts, Air Reduction Sales Co.; E. L. Swangren, Western Electric Co. Directors for two years: C. T. Allen, Gas Products Association; H. W. L. Porth, Swift & Co.; H. S. Mann, Metal and Thermit Corp'n; J. G. Norris, Central Steel and Wire Company. Directors for one year: Robert G. Mason, Atchison, Topeka & Santa Fe Railroad; W. M. B. Brady, General Electric Co.; W. L. Senhert, Chicago Welded Products Co.; Ernest Lunn, Pullman Co. Director to represent the Chicago Section at the Directors' Meetings of the American Welding Society, W. A. Slack, Torchweld Equipment Co.

Pittsburgh:

The January meeting was held on the 30th at the Fort Pitt Hotel. Mr. R. E. Kinkead, Chief Engineer of the Lincoln Electric Company, presented a paper on "First Principles in the Application of Welding in Manufacture and Repair."

Philadelphia:

The February meeting was held on the 16th, at which time Prof. A. S. Kinsey of the Stevens Institute of Technology presented an illustrated paper on "Molten Metals Under the Oxy-Acetylene Flame." The March meeting will be held on the 16th, at which time Mr. G. O. Carter of the Linde Air Products Company will talk on "Construction of Trunk Pipe Lines."

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the number Indicated in Each Case and Mailed to Society Headquarters.*

Positions Vacant

V-21. Welder wanted with at least five years' experience in job welding shop, principally automobile work; must be expert on cast iron and steel, expert on preheats, who has welded cylinders cracked internally, built up worn valve seats, etc. Knowledge of aluminum welding, chassis straightening, electric welding and boiler work, desirable but not necessary; salary to start, $50.00; location, New York; chance for foremanship. Write all details just where you worked and what you did for the past ten years in confidence.

V-23. Assistant Executive. Opportunity for real live wire to connect with general repair welding and radiator works in fast growing city in north New Jersey. Established eleven years. To branch out owner needs reliable assis-

tant executive. Capital not essential. Best location and most up-to-date equipment. Man of good personality and some experience can make unusual connection as active partner. Give particulars of past experience, age and monthly income expected.

V-24. Desires services of a young man who is familiar with welding shops in metropolitan district to sell welding rods and accessories on a commission basis with very good prospects for future development.

V-26. Wanted, a good man to sell welding and cutting apparatus.

V-27. Go-Getter wanted. Need a man to go out and get business for my welding repair works in Brooklyn, N. Y. We do electric and oxy-acetylene welding.

Services Available

A-31. Acetylene Welder. Has had 15 years of experience as a welder with good all around experience in the following lines: shipbuilding, boiler and tanks works, railroad, machine shop and steel mills. Have also worked during the past 8 years in same fields as electric welder. Am at present employed as an electric and acetylene welder. Have also acted as welding instructor in the British Navy. Am 35 years of age.

A-32. Welder desires position. Has had twelve years' experience at welding in all its branches, acetylene electric and thermit. This experience has been obtained on diversified work usually found in a shop that is the largest in South America. Nine of the twelve years' experience has been in the capacity of a foreman. Am forty years old and can speak Spanish and Danish as well as English.

A-33. Foreman or welder desires position. Has had about thirteen years all around experience as an oxy-acetylene welder. Recently resigned from Mechanical Division, Dept. of Street Cleaning, City of New York. Was employed with the City for five years on general plant repair, automobile and other rolling equipment. Can weld aluminum, cast iron, etc., and understand preheating.

Bound Volumes, 1924

JOURNAL AMERICAN WELDING SOCIETY

Now Ready!

Price Per Copy to Members, $5.00

Price Per Copy to Non-Members, $10.00

Also a Few Left for Years 1922 and 1923

Order Now!

Economies Through the Use of High Purity Oxygen in Cutting*

By John J. Crowe† and George L. Walker††

HISTORICAL—Oxygen was recognized by its properties as far back as the eighth century among the Chinese, who knew that the active component of the air combines with some metals, with sulphur and with charcoal, and that this active component could be obtained pure from saltpeter and certain other minerals. Leonardo da Vinci (1451-1519) was the first European to state that the air contains two gases, but it was not until 1774 that Joseph Priestly made the first sample of pure oxygen. It is true that Scheele, a Swedish apothecary, had made oxygen in 1771-1772 from at least seven different substances, and that he had made quite an extensive study of its combination with various materials, but as his results were not printed until 1777, Priestly is generally considered to be the discoverer of oxygen.

Many other chemists worked on the air and the commonly known gases at that time, and these studies furnished the material on which Lavoisier, the great French philosopher and scientist, based his conclusions which may be said to form the foundation of modern chemistry. The name oxygen (meaning acid-forming) was given to the gas by Lavoisier, who at that time thought it was an essential constituent of all acids. From later work we know that oxygen is not an essential constituent of all acids and that oxygen therefore does not comply with the definition of its name.

OCCURRENCE—Oxygen is the most widely distributed element in nature, and it has been estimated that it makes up nearly half of terrestrial matter. It forms approximately 21 per cent by volume of the atmosphere; it makes up eight-ninths by weight of all the water on the globe; more than three-fifths of the human body; nearly half of three of the chief constituents of the earth's crust, namely, silicious rock, chalk and alumina.

Many other minerals contain oxygen in considerable proportions. It is an essential constituent of all living organisms, aside from its existence in the water of the tissues. It is absorbed by all animals during respiration and is given off in the free state from growing vegetable organisms when exposed to sunlight.

PREPARATION—Until a comparatively recent date all oxygen was produced by chemical or electro-chemical means, and some of the older users of oxyacetylene torches will tell you that the oxygen produced for welding and cutting was very expensive and that it

---

*Paper presented at the February 16 meeting American Welding Society, New York City. Copyright, 1925, by the Air Reduction Sales Co., New York.

†Engineer in charge Apparatus Research & Development Department, Air Reduction Sales Company.

††Associate Engineer, Apparatus Research & Development Department, Air Reduction Sales Company.

was about as impure as it was expensive, when judged by our present standards. Today most of the oxygen used in oxyacetylene welding and cutting is manufactured by the liquid air process.

The atmospheric air is liquefied by compressing and cooling, and the oxygen is obtained by what amounts to a distillation process. The boiling temperature of oxygen at atmospheric pressure being —182.5 deg. C. (—296.5 deg. F.), whereas the boiling point of nitrogen is approximately 13 deg. C. lower, or —196 deg. C. (—320.8 deg. F.).

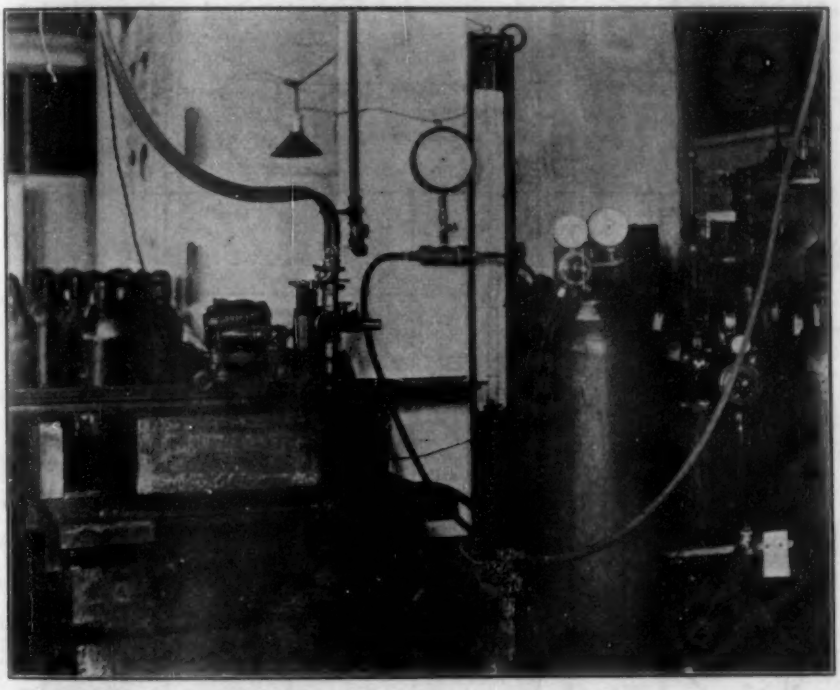


Fig. 1. Apparatus used in making tests

Oxygen has many uses, one of the recent applications being its use as an explosive in the liquid state with powdered carbon, but the use with which we are interested in the present discussion is its application to the oxyacetylene process of cutting.

DISCOVERY OF THE OXYACETYLENE PROCESS—The discovery of the principle of the oxyacetylene torch was first announced by that famous French physicist, Henri LeChatelier, in 1895 in a paper read before the Academie de Sciences on the temperatures of flames. He stated at that time that the temperature of the oxyacetylene flame was 1000 deg. C. higher than the oxyhydrogen flame, and we know today that the temperature, approximately 3480 deg. C. (6300 deg. F.), exceeds that of any other

known flame and closely approaches the temperature of the carbon arc.

Practical application was made of the principle of the oxyacetylene flame by Fouché and Picard when they developed the first oxyacetylene torch in 1901.

APPLICATION—The first torches were for welding, but it was not long before application was made of the principle of iron and steel combustion in an atmosphere rich in oxygen when raised to their ignition temperatures. We are all familar with the classic experiments made by chemstry teachers wherein a piece of watch spring with burning charcoal or sulphur attached is lowered into

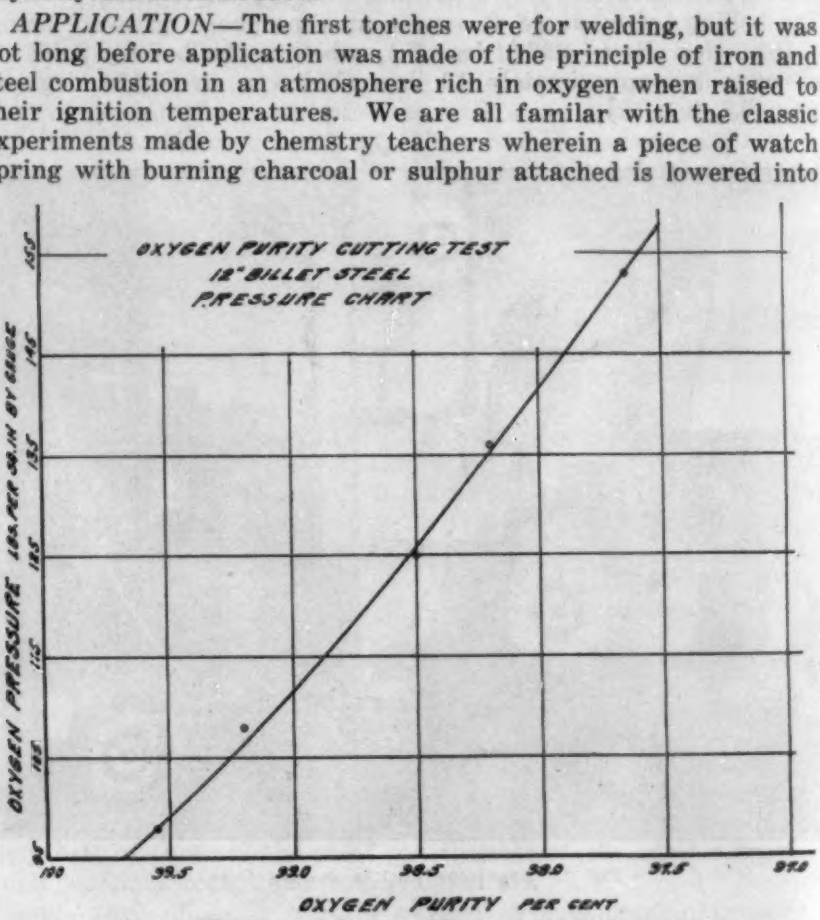


Fig. 2. Pressure required for different purities of oxygen

a jar of oxygen. The steel spring is ignited by the burning charcoal or sulphur and burns freely in the oxygen rich atmosphere. This is the principle employed in the present day modern cutting torch which has found such wide use in the scrapping of battleships, old railroad cars, cutting scrap to charging box size for open-hearth steel furnaces, and for cutting machine members to shape, etc.

OXYGEN PURITY—Until quite recently oxygen users were contented with oxygen of 97-98.5 per cent purity, but today, at least in the United States, such is not the case. By improving the apparatus and operation of liquid air plants it has been found

possible to manufacture, commercially, oxygen of much higher purity. By stages the purity of oxygen has been increased, until now it is possible to obtain continuously by that method oxygen with a guaranteed purity of 99.5 per cent, plus or minus a tolerance of 0.1 per cent.

The question naturally arises, what benefits are to be derived from small increments in purity as we approach the ultimate limit of 100 per cent oxygen, and to answer this question our company has carried out two series of experiments extending over a period of several years, and it is the results of these experiments which are presented in this paper.

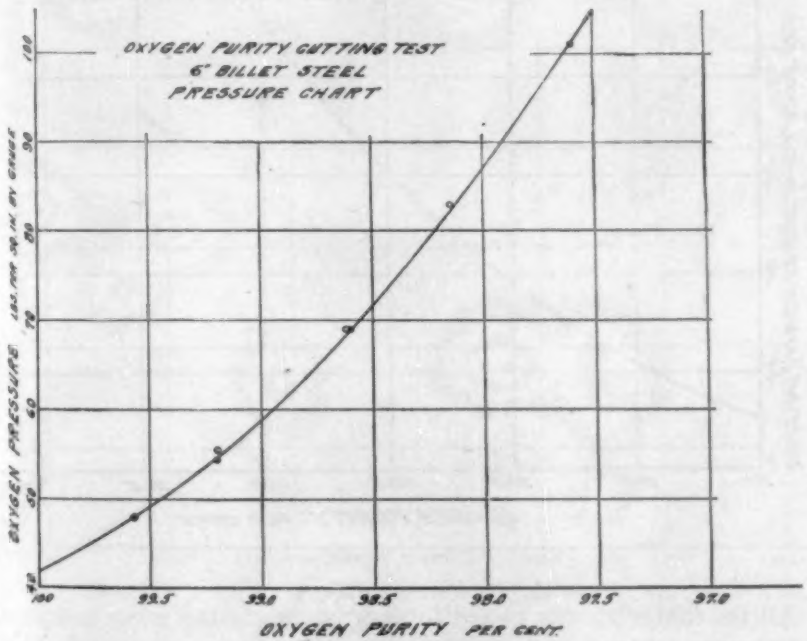


Fig. 3. Pressure versus purity of oxygen

METHOD OF TEST—The experiments were made on steel plates and rolled steel billets, ranging in thickness from $\frac{3}{8}$ inch to 12 inches. To eliminate the human element or personal equation as far as possible, all the cutting done in the first series was done with a hand torch mounted on a machine (Radiagraph) geared to give variable speeds from a few inches per minute up to 60 inches or more per minute, and in the second test series the cuttng was done with a machine torch mounted in the same manner (See Fig. 1).

The speed of the Radiagraph was checked with a stop watch. The pressures, where practicable, were measured with mercury manometers, and the higher pressures were measured with standard test gages, frequently calibrated and tested on a dead weight

gage tester. The gas (oxygen and acetylene) consumptions were obtained by weighing the cylinders before and after using, on scales accurate to ¼ ounce, and these weights were checked up, making up the loss in weight with shot and then weighing the shot on a separate balance.

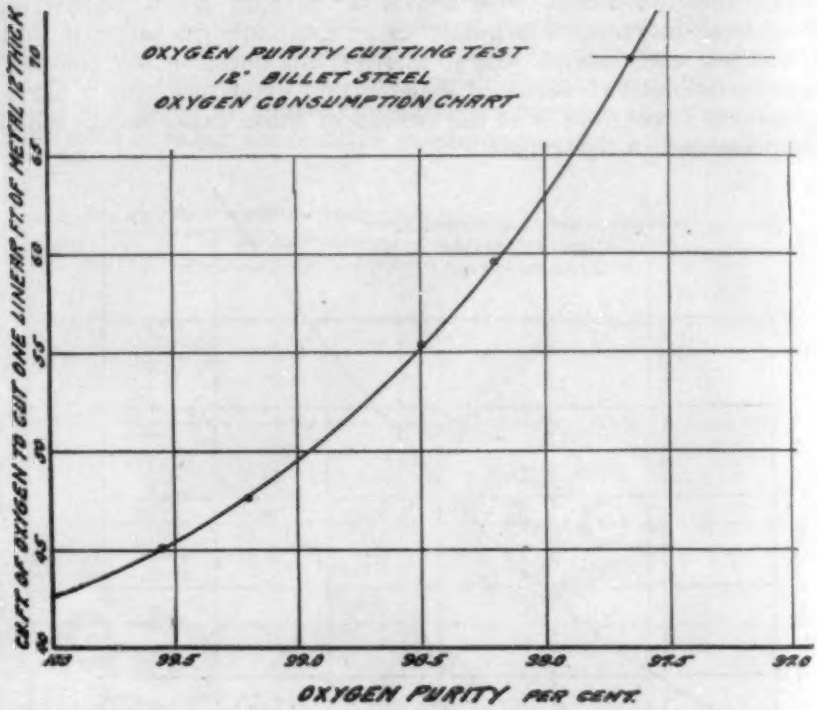


Fig. 4. Oxygen consumption chart

All the material was cooled to approximately the same temperature before cutting, and in short the experiments were carried out under laboratory conditions in which every possible variable was controlled as closely as possible.

The laboratory was furnished with an ample supply of oxygen varying in purity from 98.5 per cent to 99.5 per cent by steps of approximately ¼ per cent for the first series and from 97.5 per cent to 99.5 per cent by ½ per cent steps for the second series.

The actual purities were determined at the time of manufacture and were carefully checked in the laboratory by the method described in the appendix.

Previous experiments in which oxygen of various purities manufactured by the electrolytic process compared with oxygen of the same purities manufactured by the liquid air process had shown no measurable difference.

RESULTS OF TESTS—In the typical graphs shown in Figs.

2 and 3 the minimum pressures required to cut the 6-inch and 12-inch thicknesses have been plotted against the purity of the oxygen used. To determine these pressures a large number of preliminary cuts were made on each thickness of metal with oxygen of each purity. The method of procedure followed was to start with a pressure that would make the cut without difficulty, and then to reduce the pressure by stages until the minimum pressure was found that would just make the cut.

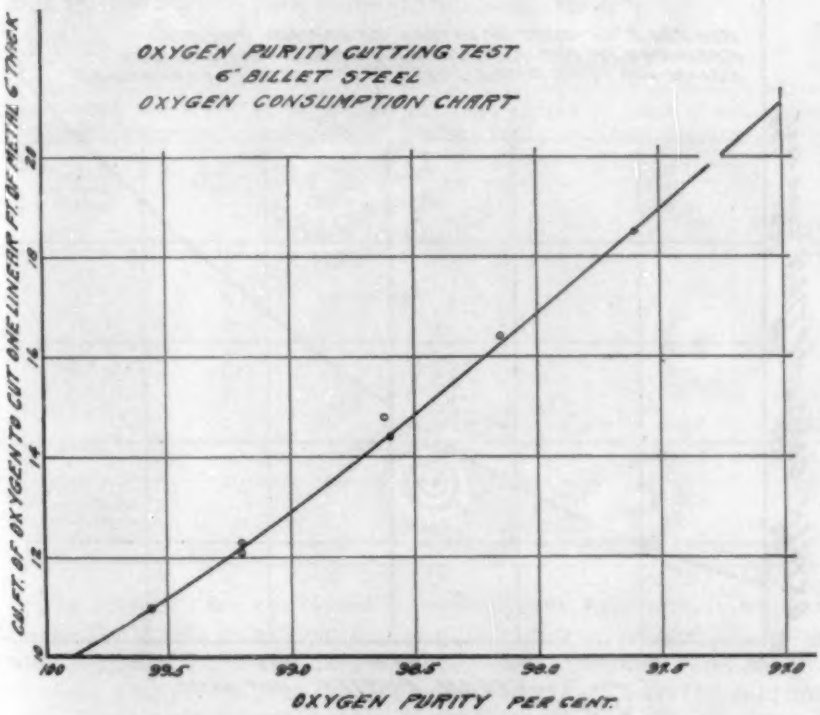


Fig. 5. Oxygen consumption chart

Preliminary experiments were also made to determine the most economical size of tip and the speeds to use in making the final cuts. The curves shown are concave upwards, but only slightly so, and this is typical of all curves plotted in this manner.

Taking Fig. 2 as an example, it will be noted that the pressure required to cut a billet 12 inches thick, using oxygen of 99.5 per cent purity, was 99 pounds per square inch, whereas it required a pressure of 112 pounds when the oxygen purity was reduced 0.5 per cent—99.0 per cent—and if the purity was dropped to 98.0 per cent the pressure required was increased to 142 pounds.

As the cutting tip was the same for all cuts on the same thickness of metal, the oxygen consumption for the same amount of cutting increases with the pressure required to make the cut.

The next series of curves, Figs. 4 and 5, show the number of cubic feet of oxygen of the various purities required to cut one linear foot of the metal thickness given on each curve. The consumptions given correspond to the lowest possible pressures it was found possible to use.

In order that the data obtained may be more easily compared they have been tabulated in Table I after reducing to a common basis, that is, the number of cubic feet of oxygen of the various

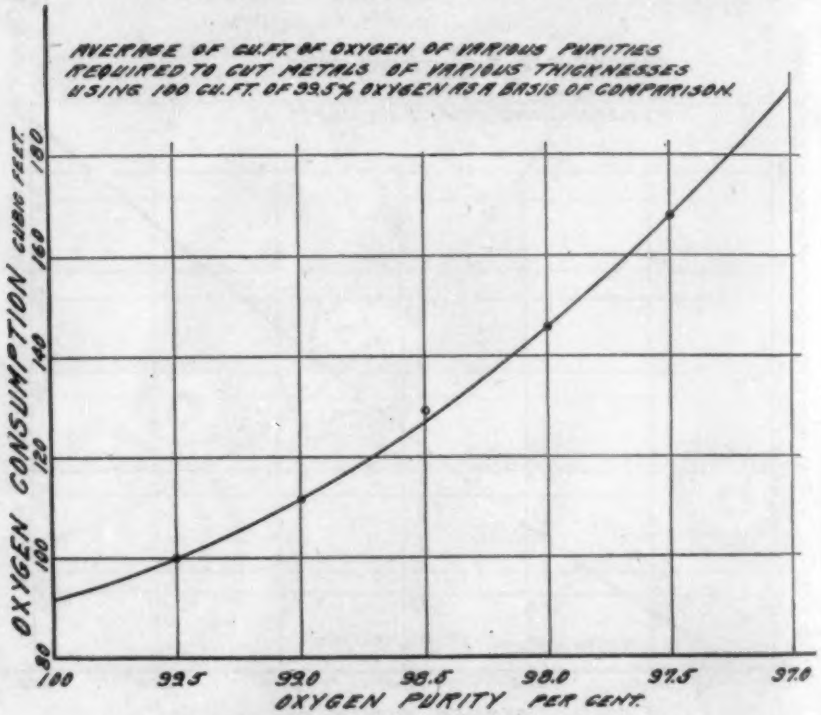


Fig. 6. Consumption versus purity for cutting metals

purities required to cut metals of the various thicknesses, using 100 cubic feet of 99.5 per cent oxygen as a standard of comparison. The mean of the results given in the table are shown graphically in Fig. 6.

It will be noted that 11.9 per cent more oxygen of 99.0 per cent purity is required to do the same amount of cutting as was done with oxygen of 99.5 per cent purity, and when the oxygen purity was dropped from 99.5 per cent to 98.5 per cent the increase in consumption was 29.2 per cent. In other words, it required 129.2 cubic feet of 98.5 per cent oxygen to make the same length of cut as was made with 100 cubic feet of oxygen having a purity of 99.5 per cent.

The preceding data have shown how the oxygen consumption increases with decrease in oxygen purity without reference to time.

The results of time studies made in the first series of experiments on sizes up to 4⅜ inch thickness are given in Table II. Owing to the large amount of material involved, these experiments were not extended to cover the larger sizes, all the cutting on the 6-inch and 12-inch thicknesses being made at constant speed. The actual time to make the various cuts is shown in Table II, and in order to compare the results they have all been reduced to a common basis and expressed in percentages, using the time obtained with 99.5 per cent purity oxygen as a standard of comparison.

TABLE I—CONSUMPTION OF OXYGEN

Oxygen consumption of various purities required to cut metals of various thicknesses, using 100 cu. ft. of 99.5 per cent oxygen as basis of comparison.

Thickness of Metal, Inches	Series No.	OXYGEN PURITY				
		99.5 Per Cent Cu. Ft.	99.0 Per Cent Cu. Ft.	98.5 Per Cent Cu. Ft.	98.0 Per Cent Cu. Ft.	97.5 Per Cent Cu. Ft.
½	1	100.0	114.1	125.5		
½	1	100.0	111.1	121.5		
¾	1	100.0	116.0	140.0		
1	1	100.0	115.4	135.0		
2½	1	100.0	108.0	123.4		
2½	2	100.0	112.1	127.5	148.8	173.9
4⅜	1	100.0	113.3	141.5		
6	1	100.0	108.8	133.6		
6	2	100.0	114.8	131.7	150.1	169.3
12	1	100.0	108.4	119.5		
12	2	100.0	108.9	122.0	139.0	161.0
Average Cons.		100.0	111.9	129.2	145.9	168.1
Difference for each ½ per cent increase in oxygen purity		a11.9	17.3	16.7	21.5	

The loss in time expressed in percentages very closely approximates the waste in oxygen as the purity decreases, and the two go together, that is, as the oxygen purity decreases, the time required to make a given cut goes up, as shown in Table II, and the consumption of oxygen in making the cut goes up at the same time, as shown in Table I. The average of the results expressed in percentages as shown in Table II is shown graphically in Fig. 7.

The characteristic drags obtained on the 12-inch billets with oxygen of four different purities are given in Fig. 8. For some work, such as straight line cutting, the amount of drag may not be of serious consequence, but in machine cutting of intricate shapes the drag must be maintained at a minimum, as otherwise the underside of the shape cut will not register with the top side.

To decrease the drag to correspond with that obtained with the high purity oxygen (99.5 per cent) it would be necessary to greatly increase the pressures, and it follows that the consumptions for the lower purities would be much greater than those shown in the curves and tables.

M. Piette, in carrying out an elaborate series of experiments[1] to

[1] Eliminating the Oxygen Waste, the Welding Engineer, Volume 9, No. 12, Page 25.

determine methods of eliminating oxygen waste, selected oxygen having a purity of 96 per cent as representing the lower limit of oxygen purity used in France. The results obtained by M. Piette with oxygen of 96 per cent purity have been plotted in Fig. 9, and the corresponding results obtained by the authors with 99.5 per cent oxygen have also been plotted to the same coordinates. The average of the results show that it requires 251 cubic feet of 96 per cent oxygen to do the equivalent work done with 100 cubic feet of 99.5 per cent oxygen.

TABLE II—TIME REQUIRED TO MAKE CUTS

Actual time required to make cuts of given lengths of metals of various thicknesses using oxygen of various purities and time expressed in percentages using time required with oxygen of 99.5 per cent purity as a standard.

Thickness of Metal, Inches	OXYGEN PURITY														
	99.50%			99.25%			99.00%			98.75%			98.50%		
	Time to make cut		Per Cent	Time to make cut		Per Cent	Time to make cut		Per Cent	Time to make cut		Per Cent	Time to make cut		Per Cent
	Min.	Sec.		Min.	Sec.		Min.	Sec.		Min.	Sec.		Min.	Sec.	
3/8	74	18	100	79	51	107.3	84	45	114.0	91	30	123.1	93	24	125.5
1/2	42	15	100	43	13	102.3	46	54	111.0	48	42	115.2	51	15	121.3
3/4	35	45	100	38	3	106.4	41	27	115.9	48	48	122.5	50	5	140.1
1	35	20	100	37	18	105.6	40	45	115.3	43	0	121.7	47	39	135.0
2 1/2	26	7	100	27	4	103.7	28	12	108.0	29	40	113.7	32	14	123.5
4 3/4	14	29	100	15	25	106.5	16	25	113.4	18	32	128.0	20	27	141.3
Mean			100			105.3			112.9			120.7			131.0
Difference for 0.25% in oxygen purity				5.3%			7.6%			7.8%			10.3%		
Difference for 0.50% in oxygen purity				12.9%						18.1%					

The Bureau of Standards, Washington, D. C., as stated in a paper[2] published under date of December 28, 1921, decided to use oxygen of 98.3 per cent purity as best representing the average purity available at that time. The Bureau of Standards found that the range of purity was 97.2 to 99.3 per cent.

PRACTICAL TESTS—It was not the purpose of this investigation to enter into any considerable number of practical applications in cutting with high purity oxygen and the results obtained, but anyone interested can easily demonstrate the superior cutting properties of high purity oxygen by making simple and practical tests if they will obtain oxygen of, say, 99.5 per cent purity and oxygen of 99.0 per cent purity or less and make cuts in the same steel plate or forging with both oxygens.

[2] An investigation of oxyacetylene welding and cutting blowpipes, with special reference to their designs, safety and economy in operation, by Robert S. Johnston, Bureau of Standards Technologic paper No. 200.

If the cutting pressures are held equal and constant it will be found that there will be a very appreciable difference in the speed of cutting, that is, if the pressures are held equal the length of cut in a given time will be considerably greater for the oxygen having the higher purity. It will also be found that if the speeds of cutting with both qualities of oxygen are held constant and equal that a much lower pressure can be used with the oxygen having the

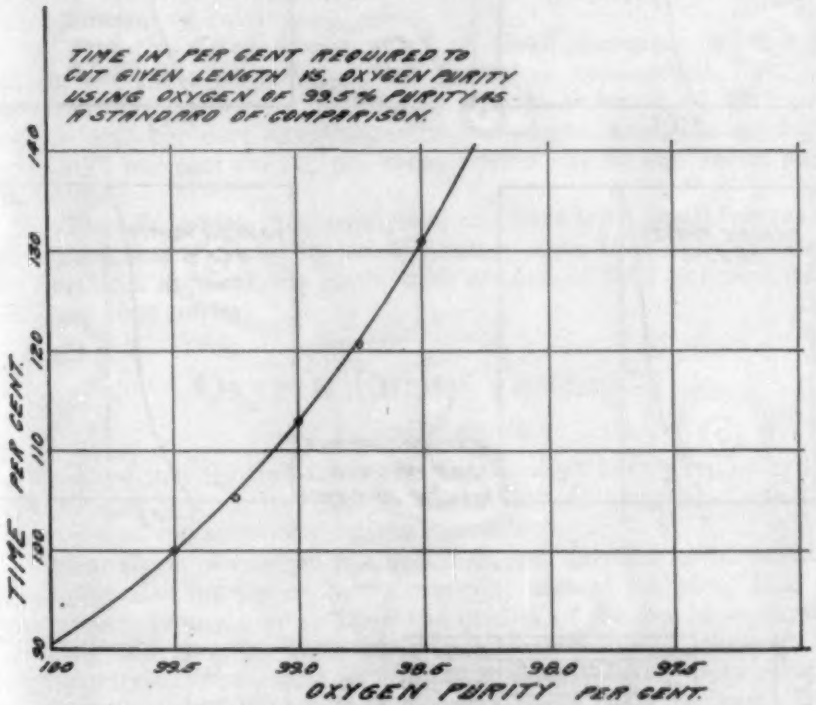


Fig. 7. Time versus purity of oxygen

higher purity, and still maintain the cut. Thereby the consumption is reduced, that is, by holding the speeds the same and properly adjusting the cutting pressures, which will be different for each purity, a considerable difference in oxygen consumption will be shown in favor of the higher purity.

As a field check on the investigation made in the laboratory, a large number of oxygen cylinders analyzing 99.5 per cent and an equal number of oxygen cylinders analyzing 99.0 per cent were used for wrecking steel cars, and a careful study was made of the results obtained with the two oxygen purities. Ten cars were scrapped with each purity of oxygen, and to eliminate as far as possible the personal equation the operators were frequently changed from one oxygen purity to the other, and at no time were the operators informed as to the purity of the oxygen supplied them. Weather conditions were bad, the temperatures ranging

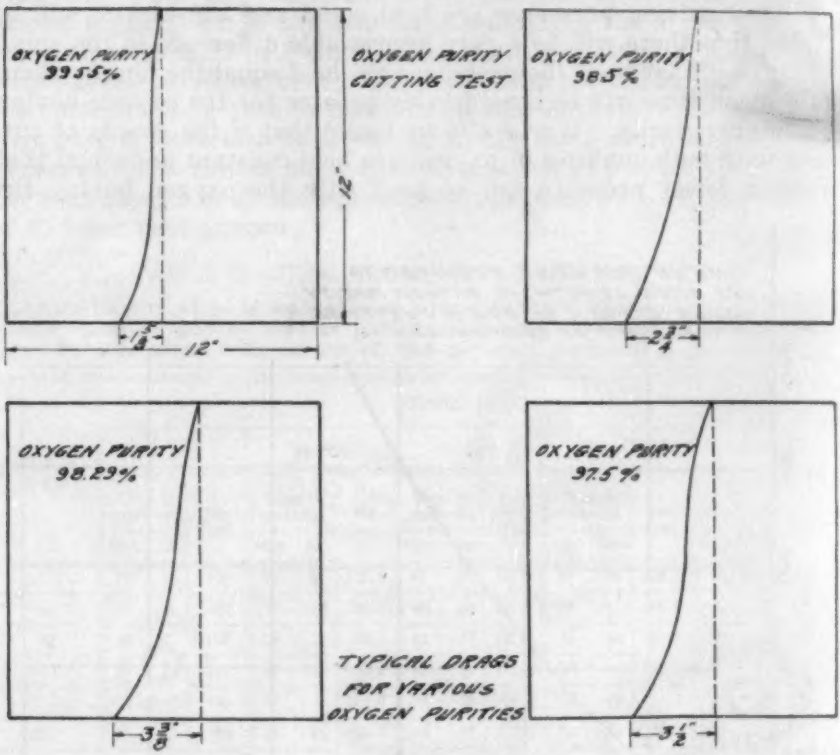
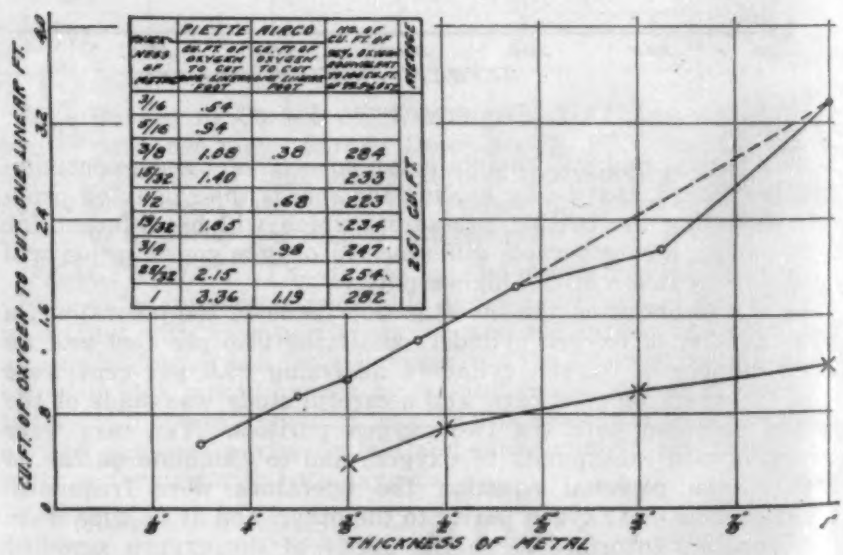


Fig. 8. Drags versus purity of oxygen



THICKNESS OF METAL	PIETTE Cu. Ft. of oxygen to cut one linear ft.	AIRCO Cu. Ft. of oxygen to cut one linear ft.	No. of cu. ft. of oxygen equivalent to one cu. ft. of acetylene
3/16	.54		
5/16	.94		
3/8	1.08	.38	284
15/32	1.40		233
1/2		.68	223
13/32	1.85		234
3/4		.98	247
25/32	2.15		254
1	3.36	1.19	282

Fig. 9. Volume of oxygen required for various thicknesses of metal

from —30 deg. F. to +21 deg. F., and the cars were covered with snow. Working under these conditions and with operators some of whom had only a limited experience in oxyacetylene cutting, a saving of 10 per cent was shown in oxygen consumption and 11.2 per cent saving in time, both in favor of the oxygen having a purity of 99.5 per cent.

CONCLUSIONS: 1—That small increases in oxygen purity greatly increase the efficiency of cutting operations, both as measured by oxygen consumption and by time required to complete a given amount of cutting.

2—That the difference of effect of small increases in oxygen purity decreases as 100 per cent purity is approached, but the effect is of considerable magnitude for the interval of 99.0 per cent to 99.5 per cent oxygen purity showing a saving of approximately 12 per cent for oxygen consumption and an equivalent saving in time.

3—That decreases in consumption and time with small increases in oxygen purity found by the laboratory have been substantiated by practical applications made with oxygen of 99.5 per cent and 99.0 per cent purity.

Oxygen Purity Testing*

BY F. P. GROSS, JR.†

We have just learned from Mr. Crowe what high-purity oxygen means, and how an increase in the quality of oxygen affects the efficiency of oxyacetylene cutting operations.

The analysis of oxygen is important, not only for experimental tests, but also for the ordinary everyday uses of the gas. It is of importance to any user to know the quality of the gas he is buying in order that he may take advantage of that higher efficiency of high-purity oxygen. Just as most commodities must meet certain specifications and have certain properties, so must oxygen. The analysis of iron or steel readily determines its physical properties —the analysis of oxygen in the same way will determine whether an oxyacetylene operation can be made with the highest efficiency. Interpreted, this would mean the use of minimum amounts of both oxygen and fuel gas in the shortest space of time, and the lowest labor and cylinder handling costs.

The procedure for analyzing oxygen is quite simple. Tests may be made easily and quickly at any time. A user of the gas may have oxygen tested in his own plant—as many are actually doing today—to determine its purity. Since oxygen now is usually sold on the basis of certain purity specifications, the test serves as a means of determining whether each shipment meets these specifications.

---

*Presented at the February 16 meeting of the American Welding Society, New York.

†Air Reduction Sales Company, New York.

This brings out the point, too, that not only must the oxygen be of high purity to obtain the highest efficiency, but it must be continuously so.

For experimental work it is absolutely necessary to know the purity of the oxygen used, and for everyday use it is just as important to know the purity of the gas used in order to obtain the highest efficiency possible and to insure continuously a supply of oxygen that gives that efficiency.

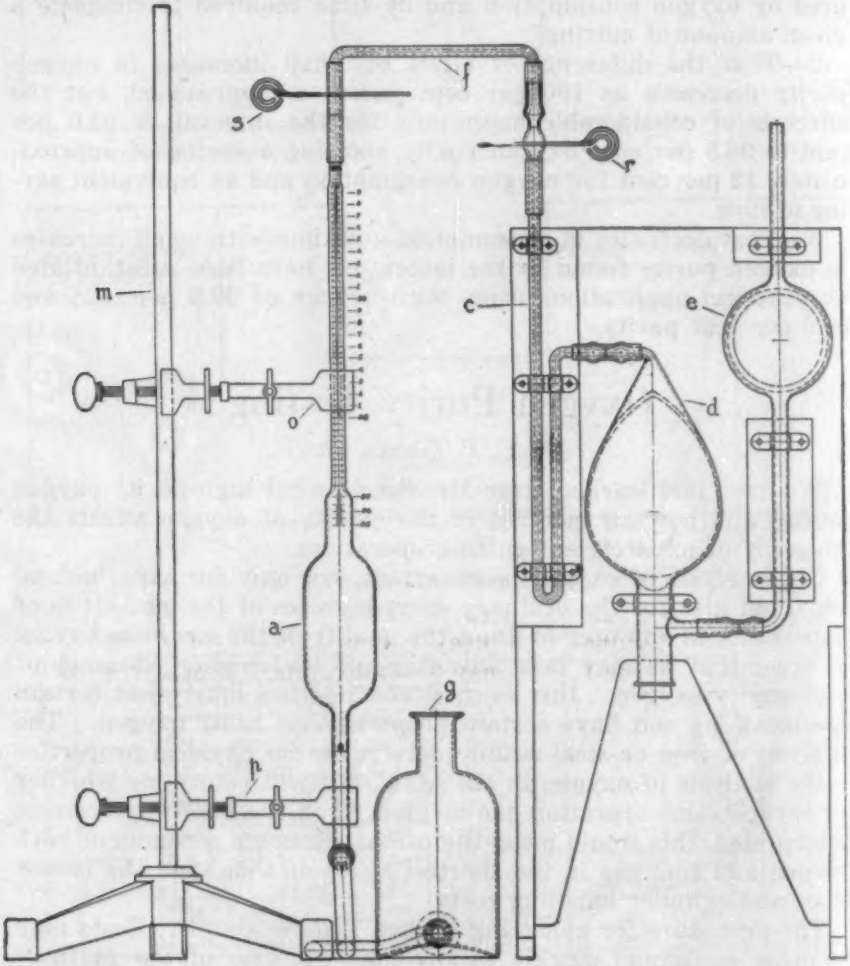


Fig. 1. Apparatus Used in Testing the Purity of Oxygen

It may not be convenient for the average buyer of oxygen to analyze the gas himself. To provide for those cases there are in most of the larger cities of the country commercial testing laboratories adequately equipped for this work that charge a nominal fee for a test.

As previously stated, the procedure in making an oxygen analysis

is simple. It consists in taking a certain volume of the gas representing 100 parts, removing all the oxygen and then measuring the volume of the residue. One hundred parts minus the residue gives the volume of oxygen present in the original sample, or, the parts of oxygen in 100 parts of gas, that is, the oxygen content in per cent. Hence we have the per cent purity of the gas tested in terms of oxygen. And so we speak of the purity of ordinary commercial oxygen. An oxygen sample testing 99.5 shows a residue of gas other than oxygen of 0.5 per cent.

TESTING APPARATUS—The apparatus required must consist of two essential parts—one to measure the sample and the residue or impurity accurately, and the other to remove the oxygen only without absorbing any of the impurities. The measuring part is the burette and the oxygen absorption part is the pipette. With this apparatus at hand we have a burette—the measuring device —that is both convenient and accurate. It is graduated or marked in such a way that very close and accurate readings may be obtained, being divided into 1/100 of 1/100, or 1/10000 parts of the original volume. This minute graduation is obtained by shaping the burette so that the residue to be measured is contained in the small diameter stem.

The human eye can easily read, say, lines 1/32 inch apart. Now if we draw two lines approximately that distance apart on a cylinder of large diameter we have a much greater volume inclosed than between two similar lines on a cylinder of smaller diameter. The larger the volume read, the greater the error involved by one division. Here in this apparatus we have the stem of the burette of small diameter, so that the space between two divisions, or graduations, represents only 1/10000 part of the whole volume measured. In the lower portion the burette is of much wider diameter, so that it will not be unnecessarily long. No readings are ever taken in this portion, of course, and so no chance for error is introduced. It is on the stems at either end of the bulb that the readings are always made.

The burette holds 10 milliliters, or cubic centimeters, or just simply the 100 parts mentioned previously. Hence we have the piece of apparatus so finely graduated that the purity reading may be made to 1/100 of one of these parts. Not only must the readings be thus easily taken, but the markings on the burette must be calibrated and etched so as to be accurate. The calibration is done in a certain definite way, as with all chemical measuring apparatus where accuracy is essential.

The pipette, or oxygen absorbing device, contains metallic copper in small coils to insure large surface and a solution consisting of NH_4OH (ammonium hydroxide, ammonium hydrate, or aque ammonia) and NH_4Cl (ammonium chloride or sal ammoniac). This absorbs the oxygen efficiently by first oxidizing the copper and then dissolving the oxide film in the solution.

Electric Power Supply to the Welding Industry*

CLIFFORD W. BATES†

An electric service company which has the exclusive right to supply electrical energy in a large city with extensive manufacturing interests has a great variety of loads of widely differing characteristics. Some loads are very uniform throughout the day, or even the month, while other loads require power for only short, infrequent intervals, with still others of a more or less intermediate character. The first mentioned type has what is called a high load factor: it requires the provision of a certain amount of generating capacity, transforming capacity, etc., and then proceeds to use that capacity almost continuously. The second type has a low load factor: it may require in a particular instance the provision of the same amount of generating, transmitting and transforming capacity, and then proceeds to use it for only a short time. It is, of course, much more expensive to supply energy to the second class than to the first per unit of energy consumed, and if it is possible to do so the second customer should pay more for each unit which is used. This requires the working out and establishment of a fairly complicated method of metering and billing, but if it is not carried to an extreme the purpose is justified. Briefly, the aim should be to have each customer pay for the cost of serving him (together with a reasonable profit to the company) and not to require the customer with a desirable load to pay the excess for serving the undesirable load.

A few words regarding the details of the costs of supplying service will make this idea clearer. There are three principal classes of costs encountered in serving any customer: (1) those which are proportional to the amount of energy used; (2) those which are proportional to the greatest demand for power, and (3) those which are practically independent of either. The most important element of the first item is fuel. The fuel burnt is almost the same if 100 kw. is supplied for one hour or 1 kw. is supplied for 100 hours. The second item is made up largely of the annual charges on the investment required in the generating station, substations, distributing lines, transformers and metering equipment. Even if the investment is not used, or is used only for short periods, the charges on the investment are the same and must be met. The third item includes such costs as metering and billing. It costs practically as much to read the meter, compute and render a bill for a small residence as for a large factory. Yet one bill may be for 50 kw.-hr. and the other for 50,000 kw.-hr. The cost will not be far from $1, which will amount to 2c. per kw.-hr. in one

*Presented at the March, 1925 Meeting of the New York Section, A. W. S.
†Research Assistant to the Chief Engineer, The Philadelphia Electric Company

case and 0.002c. in the other. This shows one reason why electricity should cost so much for residences as compared with stores or factories. Incidentally, the total cost of supplying electricity by burning fuel will not average much more than by water power, but the distribution between items 1 and 2 will be very different.

Electricity is supplied to the welding industry by the ordinary electric service company in two very different ways: (1) the direct supply to the user of welding equipment for use in electric welding, using spot, butt or arc welders, and (2) for the manufacture of oxygen. In such places as Niagara Falls it is also supplied in very large quantities for making calcium carbide. It may surprise you to know, as it did me when I first found it out, that our company supplies much more energy for making oxygen than it does for electric welding, and, furthermore, the type of load is such that gas welding is much more profitable to us than electric welding.

The conditions of the supply of power to any class of customers by an electric service company naturally depends to a considerable extent on the supply to other classes of customers, since in most cases a group of services is supplied from one sub-station, a single distributing circuit, an individual transformer, or even from one group of service wires. The quality of the service given to all the customers who are supplied from a common group of facilities must necessarily be the same, or nearly so, and although one customer might be satisfactorily served by service of a given quality, this same service might be intolerably bad for his neighbor. For example, a fluctuation of voltage of 5 or even 10 per cent is almost unnoticeable when applied to machine shop motors, or to elevators, but a much smaller variation is very objectionable in lighting installations. Again, an interruption of service of a minute or so is of no great importance in a machine shop, but may cause great inconvenience if experienced by the elevator service of an office building, or hotel, and may cause a panic in a theater or in a department store.

In consequence of this condition, and since it is out of the question to provide individual circuits, or even separate transformers, to any customer except the largest from the standpoint of demand, it is necessary to provide a high quality of service to all customers and to require that no customer's load shall cause interference to his neighbor. This naturally involves considerable expense in the case of badly fluctuating loads of even a comparatively moderate size. Under ordinary circumstances the service company absorbs this expense, but since the customer ultimately pays the bill, this means simply that the cost of service to all customers is increased. However, when a case of particularly aggravated interference arises, such as a spot welder in an installation of otherwise small demand, or an arc welder in an automobile repair shop located in a residential district, it is only just that the expense of the additional facilities—transformers and secondary copper—should

be borne by the customer who necessitates them. As will be seen later, the additional facilities necessary are often of very appreciable amount.

About the time when our country entered the World War the use of electric welding equipment began to increase by leaps and bounds. Our company had previously been able to take care of the isolated cases of disturbance caused by spot welders without having any very definite policy regarding either the increased facilities necessary to prevent disturbance or the cost of providing for these facilities. However, when welding equipment began to be used so much more extensively, it became necessary to investigate welder characteristics in order to enable the apparatus to be supplied with energy without causing trouble and without undue expense to the company and ultimately to all customers. I was detailed to look after this work and have followed it to a considerable extent since then. Several years ago the methods which we followed in charging for electricity supplied for welding purposes were questioned in a complaint brought before the Public Service Commission. As a result, a very extensive series of tests was made jointly by the commission, one of the manufacturers and ourselves, which established the standard method of testing spot welders for the State of Pennsylvania as prescribed by the commission. This method has since been adopted by the A. W. S. and the A. I. E. E. as the standard method for making input tests of welders while making welds of short duration.

The characteristics of various types of electric arc welding apparatus can be readily visualized by comparison with shop machinery. A single direct-current arc operated from a motor-generator set can be compared to an ordinary motor driving a line shaft in a small machine shop in which only one machine tool is used at a time. The load fluctuates from the light load value equal to that required to drive the shaft to the load value as required by the machine tool. A multiple arc welder is equivalent to the same number of machine tools driven from a common line shaft. The duration of the period during which a fairly steady arc is maintained is comparable to the time required in drilling a single hole, grinding a tool, etc. Similarly, an alternating current arc operated from a transformer may be compared to a machine tool driven by a large individual motor and which is used for fairly light work, such that the power factor never approaches the full load value. Any of these forms of welding may be supplied under the same conditions as a motor driving the equivalent load and which is rated to take the same k.v.a. per phase as the welder. It is evident that a machine tool driven by a two-phase 30-hp. motor which would require about 15 k.v.a. per phase could never be tolerated in a garage in a residential district without special provision being made for service. Neither could an alternating current arc welder which requires about the same k.v.a.

The characteristics of the spot and butt welder on our circuits and also those of their operators was determined by the investigation previously mentioned. The following table shows a summary of the average operating conditions, together with the extremes as we have observed them, to operate our lines. It should be borne in mind that they will change materially with the type of work to which they are applied. At the time of this investigation it was the custom to rate welders of all kinds in kilowatts, a practice which has now been discarded in favor of the kilo-volt ampere. Also at this time the approved method of testing the momentary load drawn by spot welders had not been developed, so that the results are open to some error, which, however, is probably not over 20 per cent in any case and usually much less.

Table I—Summary of Tests on Spot and Butt Welders

	Spot Welders	Butt Welders
Amps. per kw. of rating (220 volts)	0.55 to 20.7	0.87 to 6.40
	6.50 avg.	2.65 avg.
K.v.a. per kw. of rating	0.13 to 4.64	0.20 to 1.43
	1.40 avg.	0.60 avg.
Kw. per kw. of rating	0.08 to 2.00	0.19 to 0.63
	0.60 avg.	0.36 avg.
Per cent power factor	24 to 89	25 to 89
	49 avg.	56 avg.

This summary shows that a 20-kw. spot welder may on the average be expected to use power at the rate of 12 kw. during the short time of operation, and at a power factor such that the k.v.a. required will be about 28.0. However, the welder may be used under such a light load that less than 2 kw. will be used or under such a heavy load that 80 or 90 k.v.a. may be drawn by the welder. Particular attention is called to these figures, as the low power consumption shows the possible small return to the electric service company and the large k.v.a. consumption indicates the large investment which must often be made. Of course, these extremes never occur in the same installation, but the figures show how little the name plate rating of a welder actually shows regarding the requirements or returns of such an installation.

A similar summary of A. C. arc welders is given in Table II. It should be noted that this table gives the actual loads of a single arc transformer and not the load per kw. of rating as in the other table.

Table II—A. C. Arc Welders

Amperes	Average	65
	Extremes	33 to 101
Kw. input	Average	4.0
	Extremes	1.2 to 7.4
Kva. input	Average	14.1
	Extremes	7.5 to 22.2
Power factor	Average	31
	Extremes	11 to 49

While the A. C. arc welder is not a particularly desirable load, it can usually be accepted on the basis of 15 k.v.a.. without causing an undue amount of trouble.

The question of voltage regulation has been given considerable attention by our company. So far as the welder itself is concerned wide variations are permissible. If the resulting line voltage is low when an A. C. arc welder is in use, a higher tap may be used to obtain sufficient arc current and much the same condition results on the resistance types. However, if two or more welders are in use on the same service, they may interfere with each other. It has been found that 13 per cent drop from no load to welding load represents about the limit of satisfactory operation for any type—either arc or resistance. If absolutely no other load is connected to the service transformer, it and the secondary lines between it and the welder may be quite small, merely sufficient in its rating to supply the maximum load which may usually be taken as one k.v.a of transformer rating (with corresponding wire size) for each k.v.a. of welder rating.

When, however, motors or lights are to be operated from the same transformers, the conditions are much more difficult to satisfy. Most State Commissions specify a standard of regulation of voltage for both light and power service. In Pennsylvania the Commission specifies "that for service under lighting contracts and under power contracts the voltage variations shall not exceed plus or minus 5 per cent and 10 per cent respectively of the standard service voltage for more than one minute." This is typical of all commission requirements, but most service companies try to give much better service. Our own company attempts to limit the drop to 1.5 per cent for lights.

In order to approach these figures, it is necessary to separate, as far as possible, the welder supply wires from those supplying lights and motors. The drop in an ordinary transformer from no load to full load will range from 3 to 4 per cent on low power factor loads, i.e., from 6.9 to 9.2 volts on a 230 volt winding. Using 115 volt lamps the voltage variation across the lamp will be 3.5 to 4.6 volts or 1.5 to 2 per cent. It will be seen that this gives little margin for line drop outside of the transformers, and since a flickering or fluctuating light is much more annoying than a dim light which has a steady intensity equal to the low extreme of the flicker, we have considered that the effect of the fluctuation due to welder should be limited to about half the value given above, or to ¾ to 1 per cent. That is, a transformer which is to supply other loads in addition to the welder must be roughly twice the size (in k.v.a.) of the welder supplied by it. Our working rule formulated before the adoption of the k.v.a. rating for welders is that the k.v.a. rating of a transformer shall be at least 2.0 to 2.5 times the kw. rating of the welder. On this basis the 20 kw. welder used as an illustration would be supplied by a 40 to 50 k.v.a. transformer. The necessity of using commercial sizes of transformers limits us to 50 k.v.a., the next lower size being 37.5 k.v.a. Even using this size of transformer it is necessary to run separate

secondary wires for the transformer for lights and for welder and to use separate meters. Motor loads might usually be supplied by the same wires as the welder, but it is better to combine the lights and motors, thus following the ordinary practice.

Another important factor from the economic standpoint is the time of operation of a welder. The time required to make a single spot weld varies a great deal with the requirements of the work ranging from 0.2 to 2.0 seconds, with an average of about 1.0 second, according to my observation. A typical cycle while welding a total of ⅛ in. of steel is: welding 1 second, moving piece 2 seconds, welding 1 second, etc., for 6 to 10 welds followed by an interval of 15 to 30 seconds to change and adjust a new piece. There will also be idle intervals, so that it is reasonable to assume that the welder is in use for about one-third of the time.

Butt welders operate on a more continuous cycle, being used for about one-fifth of the time on the average. Otherwise their characteristics are identical with those of the spot welders. Arc welders may be taken to be in use for one-third of the working day.

Continuing the example, I shall assume that the 20 kw. welder is used at the average load as observed, i.e., 12 kw. In a 10-hour working day it would be in use for 10 per cent of the time, that is, 1 hour. The daily use would then be 12 kw.-hr., which must be supplied by a 50 k.v.a. transformer. If this transformer were used for supplying a shop motor at 80 per cent power factor and loaded to an average of 70 per cent for the entire day it would supply 280 kw.-hr. That is, over 23 times as much energy would be sold by means of facilities which cost equal amounts. We believe that the welding customer should pay for the use of these facilities and not shift the burden to the other customers.

The method of charging for the facilities required is as follows: A transformer of the size required for the welder is installed together with secondary conductors of a corresponding size. In case the line is more than 100 ft. in length the customer may be required to finance the additional length on the usual refund basis, otherwise no installation charge is made. After the installation has been completed and production commenced, a demand test is made to determine the instantaneous maximum demand of the welder in k.v.a. when the heaviest normal production work is being done. In case there are control points which would permit the use of the apparatus for heavier work than is required, these are sealed to prevent their use. The demand thus found is used as the billing demand. This demand and the energy consumption are then used to compute the customer's bill at the rates for the class of standard contract appropriate to the case.

First Principles of Application of Electric Arc Welding to Manufacturing and Repair Work*

R. E. KINKEAD†

The application of Electric Arc Welding introduces fundamental changes in the mechanical arts which are of far reaching importance. Machinery and mechanical equipment used in all kinds of transportation, is reduced to its simplest terms—just so many pieces of metal fastened together. Since we are dealing with a different method of fastening pieces of metal together, the effect is felt throughout the entire manufacturing industry which produces such machinery and equipment. The effect of the introduction and use of Electric Arc Welding has gone further than changing the fundamental conception of how pieces of metal should be fastened together. It permits new economies in the use of material, because of the fact that standard structural steel shapes and plates may be welded together to serve the purpose of grey iron castings. The use of welding in the repair of machinery and equipment has brought about an entirely new set of conditions relative to the cost of using iron and steel equipment. It may be said, therefore, that in dealing with the subject in hand, we are dealing with one of tremendous importance, since it has brought about and is bringing about increasing volumes of revolutionary changes in methods and costs of manufacturing.

The economics of manufacture involve a great many subjects with which we may not concern ourselves here. However, the widespread application of welding in place of other mechanical methods in manufacturing has proceeded far enough for us to be able to see that welding involves the application of some of the most fundamental economic principles.

It is generally believed to be true that when it becomes technically possible to perform an operation or produce a product which is equal to the old product or better than the old product at a lower cost, that it becomes economically necessary to adopt the new method. The operation of this principle is, so far as welding is concerned, very clearly defined in the case of the tank building industry. As soon as one tank builder was able to build tanks by welding for less money than he could build them by riveting, and it was found that the tanks were better because they stayed permanently tight, it became economically necessary for practically all the tank builders to supply tanks which were welded—the salesmen selling riveted tanks could not compete with the salesmen selling welded tanks.

Another example of the same thing occurred in the welding of

*Presented at the January, 1925 meeting of the Pittsburgh Section, A. W. S.
†Chief engineer, Lincoln Electric Co.

rear axle housings for automobiles. As soon as the first large manufacturer applied the Electric Arc Welding process to work, he did it equally well for considerably less money. The net result was that everybody in the housing business had to immediately install welding apparatus to do that particular job.

Manufacturing in the lines to which welding is applicable is for the most part on such a highly competitive basis that cost reducing processes and methods must be introduced at the earliest possible moment that they become practical and feasible shop practice. Practically all applications of Electric Arc Welding may be divided into four general classes:

First—Welding in place of riveting.

Second—Substitution of welded steel for grey iron castings.

Third—Substitution of Electric Arc Welding in manufacturing.

Fourth—Substitution of Electric Arc Welding in salvage and repair operation.

The underlying principles involved in the substitution of welding for riveting are not so difficult as might appear on the surface. A riveted joint is designed to carry a certain load. The rivets are always placed so that they are subjected to a shearing strength. In applying the welding to the seam in place of the riveting, the welded material may be placed either in tension or in shear. An instance of this is the case of building a tank in which a longitudinal seam has been riveted. This, of course, is a lap seam and the rivets are normally in shear. If in the welding operation we make a butt weld to replace the riveted seam, the stress in the welded material is tension. If on the other hand we replace the riveted seam with a lap weld, welded from both sides, we replace the riveted seam with welded material which is in shear. It is evident that to do the job intelligently, substituting the welding, we must assign some value to the strength of the welded material in tension and in shear. For this purpose we use the ultimate strength in tension of the welded material as 45,000 pounds per square inch of welded material. In shear we allow 36,000 pounds per square inch of welded material.

Now, with the fundamental figures in mind, we are able to design the welded job to give the same or greater strength in the seam than is obtained with the rivets.

An occasion in which the riveted construction is closely paralleled by welded construction is where a hole is punched through one plate and the welding is done through the hole on to the plate below. We are placing the metal in shear in the same manner as if a rivet were used. In a case of this kind we recommend and practice the use of 50 per cent more metal in shear than has been used in rivets before. This practice is allowed to take care of difficulties which may occur in the welding so that 100 per cent. fusion would not be obtained. By allow the 50 per cent extra metal in shear, sufficient excess strength is allowed to be sure to obtain as much strength as was obtained by rivets.

In welding through a hole to reproduce the metal in shear due to a rivet, an additional factor must be considered—that is—that the hole must be large enough to permit the proper application of the built-in welded material. We usually require a hole two and a half times the thickness of the plate in which the hole is punched, even though this may give more metal in shear than is actually required to make the joint.

There has been a great deal of consideration and study made by interested manufacturers on the various limitations of the welding process and also the limitations of riveting. The status of the matter at the present time appears to be something as follows:

In riveting, the human factor is the determining factor and riveting cannot be relied upon unless it is inspected during the riveting operation and after the riveting operation is completed. So far as damage to the original material is concerned, in the riveting process two kinds of damage occur—in the first place, the removal of the material to form the rivet hole is not replaced so far as the tensile strength of the joint is concerned. In the second place, punched holes have material round the perimeter of the hole which has been stretched beyond the elastic limit and which is debased to that extent. The limitation of the welding appears to come from the fact that there is no reliable degree of ductility in the built-in metal and also due to the fact that there is some thermal disturbance in the metal of the original pieces joined adjacent to the line of fusion of the weld. The human factor is important in the case of welding to about the same extent as the human factor in the case of riveting. It is generally conceded by manufacturers who do both riveting and welding, that they know as much about the quality of a weld which has been inspected during and after the welding operation as they do about a riveted joint which has been inspected during and after the riveting operation.

The economics involved in the substitution of welding for riveting make an interesting study. The outstanding facts in the connection appear to be about as follows:

That it takes as much power from the power line to do riveting as it does to do welding. It takes about three times as much labor to do hot riveting as it does to do the same number of feet by welding. The output per square foot of floor space of a plant is increased from 50 to 60 per cent by welding in place of riveting. The capital charge for machinery for welding in place of riveting is from 50 to 75 per cent less in the case of the welding. The cost of rivets runs from two to three times the cost of welding rod to get the same strength in the joints.

So far as the utility of the welded steel structure, whether it be a tank, machinery base or other kind of machinery, it appears from experience that the welded job has distinctive advantages since there are no rivets to work loose. The riveted seam has the same inherent defect of working loose if there is any load upon the seam. This results in a continual and steady loss in useful

strength of the joint to stay nothing of the tightness which in the case of a joint in a tank is essential. If there is any flexibility in a riveted seam, failure of the seam has started. With the welded joint, on the other hand, the joint is permanently tight and may be made strong enough so that any flexure will come in the pieces joined rather than in the joint and the full strength of the pieces joined will be utilized.

Owing to the greater strength of the welded joint considerable savings in material may be effected since the strength of the joint in the case of riveting determines the thickness of the material which must be used in the members joined. This matter is particularly applicable to the fabrication of tanks, tension members of trusses, etc.

Replacing Grey Iron Castings With Welded Steel Construction

A great many grey iron castings are being used today because the designers are not familiar with Electric Arc Welding as a means of fastening together pieces of steel to do the same work as is now done with the casting. Until ten years ago the only alternative to using a casting was to use steel put together by rivets which was obviously impractical owing to the cost and to the fact that the inherent nature of the riveting process is such as to make it certain that the rivets will work loose if the structure is subjected to a live load. The introduction of welding and its widespread use has developed clearly that both of these difficulties are completely overcome by the use of Electric Arc Welding. Machinery is now being built using standard steel plates and shapes welded together which would cost four to six times as much if it were built in grey iron castings.

The underlying principles seem to be something as follows: In order to get a casting it is necessary to make a product. The product charge must be added on to the metal cost of the casting as a legitimate item of expense. The defectives in a foundry are also contributed to the expense of using a casting. A new casting in a foundry has to be worked on and moulding practice developed in order to get the number of defectives down to a reasonable percentage. All of this contributes expense to the practice of using a casting. Another thing of considerable importance is that the casting is an individual operation in its manufacture whereas hot rolled steel is produced on standardized shape and by high speed mass production methods.

Perhaps the most important item is the relative strength of steel and cast iron. It is necessary to use a considerably greater weight of cast iron in order to get the same strength than is necessary to use in case the piece is made of steel. Cast iron is only about one-fourth as strong as steel and since tension is the governing factor in the construction of most machinery and castings, this results in the necessity of using a large weight in cast iron in order to get the same strength as could be obtained with steel with considerably less weight. The item of stiffness is of importance in certain

machinery. Steel is more than twice as stiff for the same section as cast iron.

The cost of the two metals under comparison also favors the use of welded steel construction. Cast iron, under the most favorable conditions, will cost twice as much per pound as steel and in many cases cost three or four times as much as steel per pound. This introduces extra expense in the using of castings due to the extra cost of material, due to increased freight rates, and due to increased costs of handling the manufactured product.

Failure of cast iron machinery parts results in heavy expense for repair work. Even though cast iron may be welded, it is an expensive operation. On the other hand, frames of steel may be readily welded at very low costs. Summing up these items, it is obvious that the underlying principles of economics have been satisfied in the substitution of welded steel construction for grey iron castings. So far the work in this direction has been done in replacing the heavier grey iron castings and it appears that a considerable number of the lighter grey iron castings may also be replaced economically.

So far as the technical application of welding to the fastening of the pieces of steel together to form a machinery frame or base, the same general principles apply there as apply in connection with the fabrication of tank steel, or in the replacing of riveting by welding. The same man who designs a frame in cast iron is fully competent to design a frame in welded steel.

Replacing Other Methods With Electric Arc Welding in Manufacturing

The underlying principle which makes Electric Arc Welding more economical than the gas welding where it may be applied is that it is a more direct application of heat. The manufacture of acetylene and oxygen as a heat producing combination is carried on with an expenditure of electric power. It is far more economical to take the same electric power and convert it directly into heat in the Electric Arc Welding process than it is to go through the intermediate steps of producing oxygen and acetylene in order to get the heat.

The Substitution of Electric Arc Welding for Gas Welding in Salvage and Repair Work

The situation relative to the application of welding on salvage and repair work is similar to that in the substitution of Electric Arc Welding for gas welding in manufacturing. The largest single instance in which gas welding maintains leadership in the repair field is in the automotive industry where a peculiar set of conditions exists so far as the application of Electric Arc Welding is concerned. The small garage or repair shop which does welding is frequently unable to make the capital expenditure necessary to equip with Electric Arc Welding, whereas a relatively small out-

lay is required in order to get a gas torch and gages and start to do gas welding. In addition to this situation, there are a number of jobs encountered in the automotive industry which may be done better with the oxy-acetylene torch than with the arc torch, at the present time, such as brazing and the welding of thin metal, such as fenders. There is the added advantage of the gas torch in that it may be used for a heating unit in case a front axle is to be straightened or work of this nature—such as straightening frames, etc. This set of conditions has resulted in a large preponderance of gas welding apparatus in the repair field of the automotive industry.

The growth and adaptation of scientific methods for the solution of technical and manufacturing problems is responsible in a large measure for the progress which has been made in the application of Electric Arc Welding up to the present time. If any man is to accomplish anything in this direction he must adopt such methods in the solution of the problems involved. In the application of welding, the first concession to be made is that the facts are just the same, regardless of what you may think they are. By far the greater percentage of blunders and failures, both in the field of economics and in the field of technical work, is made because of some men's failure to get the facts. It is an easy matter to state and believe that certain things may be true—however, the statement or the belief have nothing whatever to do with the case. For instance—the distinguished head of a mechanical department of the greatest railway systems in the United States only a few years ago stated that Electric Arc Welding was not satisfactory for boiler work and that it would never be applied in the boilers over which he had supervision. Being a man of great personal force, his statement convinced a great many people that Electric Arc Welding was not adaptable to firebox work and locomotives. Yet, mountains of evidence piled up upon this man until he changed his mind and now requires all firebox welding to be done with the Electric Arc Welding process where Electric Arc Welding equipment is available. Now his forceful statement and opinion have nothing whatever to do with the facts. The facts were just the same when he made the statement as they are now when he requires firebox welding to be done with the Electric Arc process.

In the past a great many people have said with great emphasis and with every indication of sincere belief "You never can tell what is inside of a weld" and that, therefore, Electric Welding could never be used in place of riveting where strength was involved. Yet, we know from experience that with the same supervision over the welding that is normally used in the case of the riveting process, we know just as much about what is in the inside of a weld as we know about the condition of the riveted seam. Another case in which a man's opinion has nothing whatever to do with the facts.

Some years ago we had lengthy discussions and arguments as to

whether or not cast iron could be welded with the Electric Arc process. I for one was of the opinion that such a weld was not reliable. Yet, not three years after holding such an opinion, I supervised the making of scores of such welds which simply had to be reliable and accomplish the work without failure, again proving that it is not a question of what anyone thinks about it, but a question of what the facts are.

We used to think that welding could not be applied on bridges or upon the strength members of a building. Yet, welding has been applied on a number of bridges with perfect safety and no failures and there are thousands of large buildings which have their floors supported entirely by welded steel members. Now the facts in these cases were just the same before the job was done as they were after the job was done. The leaders in these fields simply proceeded on the basis of facts rather than on the basis of someone's opinion.

The difficulty with most of us is not inability to think but mental inertia and refusal to indulge in that rare mental exercise. It is so much easier to accept another man's opinion than to form one intelligently yourself, that most of us do business on other people's opinions. There are comparatively few men who are right in their opinions half the time, in fact there seems to be a general agreement among people who have thought along these lines that 90 per cent. of all people's opinions are entirely wrong. However, if any one thing may be said to be the first principle in the application of Electric Arc Welding to manufacturing and repair, it would be stated as the principle of forming opinions and drawing conclusions on the basis of observable facts rather than upon other people's opinions.

Welding Cast Iron with Bronze*

S. W. MILLER†

At first sight this does not seem a very promising process. The softness of bronze compared with that of cast iron, and the quite common thought that bronze is deficient in strength, would lead one to believe that the chances for success were small. But when we consider the facts we can easily see that there are good reasons for the great success and wide application of this method of joining cast iron.

The bronze used for the purpose is not really a bronze, which is a copper tin alloy, but a brass, or copper zinc alloy. It is not ordinary brass but contains notable amounts of iron, manganese,

*Presented at the December, 1924 meeting of the Boston Section
†Consulting engineer, Union Carbide & Carbon Research Laboratories.

tin, more or less of one or more of these elements being present. The composition usually falls in the following range:

Copper	57 to 62%
Zinc	38 to 41%
Iron	up to 1.0%
Manganese	up to 0.5%
Tin	up to 1.0%

So it seems that the composition must be restricted rather closely. The iron strengthens the alloy, the manganese helps very much in making a sound weld, while the tin increases the fluidity.

It is essential that aluminum and lead be kept out, as the former prevents the bronze from joining with the cast iron, while the lead makes a porous weld.

It is necessary that good foundry practice and special methods be used if the highest grade of rod is desired. It has also been found necessary to test carefully each shipment to be sure that the rod is of good welding quality, and does not contain undesirable elements.

I might say here that it is becoming more and more important to test incoming stocks of all rods, not only because of the growing ability of the welder to discriminate between good and bad, but for the fact that good welding necessitates good rods. Instead of taking anything offered as a rod, and suffering the consequences of poor work, the welder insists on clean, smooth working materials of good physical property. This is indeed a satisfactory condition. While it may be necessary to vary the composition of the bronze to suit different purposes, it is not wise to have several different rods around a shop, unless each rod be clearly marked, as they may get intermixed.

The advantages of the bronze welding process are:

First—Its rapidity.

Second—Only a small amount of preheating need be used.

Third—The ductility of the bronze absorbs and reduces to a safe point welding strains that would cause breakage with cast iron welding.

Fourth—The usually greater strength of the bronze makes it possible to use only small amounts when the weld design is correct.

Fifth—The low melting point of the bronze and its easy union with the cast iron, make it possible to apply it without melting the latter.

Its only disadvantage is its ductility or rather its low yield point, which makes it unsuitable for use where rigidity is needed, for example in a casting that must not give under stress. Even there it is sometimes possible to use bronze, if the unit stress is not too great. It may also be said that different alloys used for bronze welding rod have different shaped stress-strain curves, some of them having a rather definite yield point, as does steel. Such

alloys behave in an elastic manner and acquire no permanent set under safe loads.

The uses to which the process may be put may be divided into two classes:

First—Where strength is needed.

Second—Where a bearing surface must be provided.

In the first class would fall broken parts. Some unusual repairs have been so made. For instance, it is the usual practice now to repair locomotive cylinders this way. When they were welded with cast iron, it was, of course, necessary to preheat to a high temperature, and in some places, such as the ports and passages, it was sometimes impossible to avoid cracking even with the cylinder removed from the engine.

Such difficult or impossible work is now done rather easily with the cylinder in place, and it is quite common to cut a piece from the outside of the cylinder to get at an interior defect, and after the repair has been made, to weld in the removed piece, just as broken domes in automobile cylinders are repaired. The amount of preheating is small, sometimes the heat that the steam gives being enough.

The welding of cracked or broken cylinder barrels is easy and rapid, because the preheating temperature is low, and so the cylinder cools rapidly after welding because the bronze can be so rapidly applied. Further, the bronze will run into a smaller V than is needed for cast iron, and less weld metal is needed. A 75 deg. V is generally all that is needed, even in thick castings.

Any steam cylinder is designed for ease and certainty of getting a sound casting rather than on a pure strength basis, and this is especially true of locomotive cylinders. If it were only a question of resisting internal pressure, a cylinder 30 in. in diameter for 250 pounds of pressure would need a thickness of about ½ in. if good cylinder iron were used. But they are usually made from 1½ in. to 2 in. thick. Even with the minimum thickness, the factor of safety is very large. So in such cases the strength of the welded joint of bronze is ample.

A more recent application is the bronze welding or jointing of cast iron pipe instead of using the common ball and spigot joint, with which there are large leakage losses, especially when high pressure gas is being transported. Welded lines have been installed in a number of places, for instance, one 23,000 feet long and 6 in. in diameter, carrying city gas at 60 pounds pressure.

The first work that was done in this way was due to Bridge and Thompson, engineers for the Southern Counties Gas Company in California, whose test results have been published in many trade journals and pamphlets. The tests show that the ordinary V joint has less strength than the collar joint. After other tests it was found perfectly satisfactory to join cast iron pipe of either the sand cast or centrifugally cast type with a collar type of bronze weld.

Figure 1 shows a section of the joint, the basis of design being as follows:

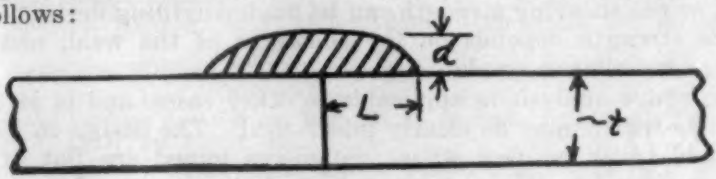


Figure 1.

Let t = thickness of pipe in inches
d = thickness of weld in inches
L = length of weld on one of the pipes
T_c = ultimate tensile strength of the cast iron, lbs. per sq. in.
T_b = ultimate tensile strength of the bronze, lbs. per sq. in.
S = shearing strength of cast iron bronze joint, lbs. per sq. in.

Then for equal strength of weld and pipe
$t \times T_c = d \times T_b = L \times S$.
If $T_c = 20{,}000$ $T_b = 35{,}000$ and $S = 40{,}000$.
$d = 4/7\ t$ and $L = \frac{1}{2}\ t$.
or for a pipe ½ in. thick,
$d = .28$ in $L = \frac{1}{4}$ in.

These dimensions evidently call for a very small amount of bronze in the weld. In fact, it is not practical to make such a small weld with bronze because of its free flowing qualities. Consequently any joint that is easily made will have L great enough, but care will have to be taken to get d thick enough.

The above refers to a joint equal in tensile strength to the pipe. But it is much stronger than needed, considering only internal pressure, as a girth seam is always twice as strong as a longitudinal one in the same pipe. In such a case, d and L would be only half these called for above.

This shows that the size of the weld depends as much on the practical handling of the rod and blowpipe as on anything else.

The usual method of fusion welding requires a V between the pieces joined, which is gradually filled up with the weld metal, which is fused to the sides of the V during welding. Thus the strength of the welded piece depends on the strength of the union between the weld and base metals. Where bronze is V welded to ordinary cast iron, and the joint is tested in tension, the break is always in the cast iron, because it is the weaker. This is, of course, where the sections are equal. Any defect in the union makes the joint less efficient. It is also evident that, when the V is filled up, the maximum tensile strength is had. It is, however, possible to make a joint always of greater strength than the cast iron, by using the shearing strength of the union between the two metals,

as in shown in Figure 1. There is no limit to the length of the weld, so the shearing strength can be made anything desired. The tensile strength depends on the thickness of the weld, and this can easily be made ample.

The above analysis is applicable to other cases, and is given in detail so that it may be clearly understood. The design in Figure 1 should never be used where the pieces joined are flat, if any pressure is to be withstood, as in a longitudinal seam of a pressure vessel. Such a joint is very weak in tension because of the eccentric loading.

CURRENT WELDING LITERATURE

Adjustable Welding Stand for Car Wheels, Electric Traction (Feb., 1925), Vol. 21, p. 86.

Aluminum, Autogeneous Welding of, Ueber die Autogene Aluminumschweissung Werkstatts Tech. (Nov. 15, 1925), Vol. 18, pp. 650-6.

Aluminum, Theory of the Autogeneous Welding of, Ein Beitrab zue Kenntnis der Theorie uber die Vorgange bei der Autogenen Aluminumschweissung, W. U. Schoop, Autog, Metallbearb (Oct. 15, 1924), Vol. 17, p. 269-70.

Arc Welding, Betrachungen uber die Elektrische Lichbogen Schweissung, W. Neubert, Werkstatts Tech. (Nov. 15, 1924), Vol. 18, pp. 640-4.

Arc Welding, Electrode for Electric, G. Motte, U. S. Pat. 1517311. Off. Gaz. (Dec. 12, 1924), Vol. 329, p. 97.

Arc Welding in Power Plants, W. L. Warner, Power (March 3, 1925), Vol. 61, pp. 336-338. Repairing cast iron flywheel, repairing feed-water heater, welding structural steel framework, arc of contact.

Arc Welding in the Steel Industry, W. L. Warner, Welding Engineer (Feb., 1925), Vol. 19, pp. 37, 38, 40. Spindles, sheet mill, blooming mill, foundry and furnaces, transportation system, pipe lines.

Bronze Welding for Locomotive Frames, J. H. Chancey, Railway Journal (March, 1925), Vol. 31, pp. 20-21.

Cast Iron, Welding. Uber das Schweizen von Gusz. F. Panssen, Werkstatts Tech. (Nov. 15, 1924), Vol. 18, pp. 637-40.

Cutting Cast Iron and Copper Alloy by the Electric Arc Process, A. G. Bissell, Machinery (Feb., 1925). Time and power consumed, other applications.

Double Welding on Locomotive Frame, Railway Journal (March, 1925), Vol. 31, pp. 21, 22. Other thermit welds.

Electric Welding, Ueber elektrische Schweissung, H. Neese, Ztsch. Ver. Deut. Ing. (Oct. 23, 1924), Vol. 68, pp. 1125-32.

Electrode Welding Rod and Soldering Stick, E. H. Jones, U. S. Pat. 1517292, Off. Gaz. (Dec. 2, 1924), Vol. 329, p. 710.

Fabricating Large Structures, H. Goldmark, W. Spraragen, W. L. Warner. The Welding Engineer (Feb., 1925), Vol. 10, pp. 23, 24. Tests on arc welded roof truss, shearing strength of welds.

G. E. Electrical Developments in Mining and Metallurgy in 1924, including Welding. Mining and Metallurgy (Feb., 1924), Vol. 6, pp. 109, 110.

Investigations of Welded Joint Committee, Railway Journal (March, 1925), Vol. 31, p. 34. Investigations Nos. 1, 2, 3, 4 and 5.

Locomotive and Car Repair, H. D. Adell, The Welding Engineer (Feb., 1925), Vol. 10, pp. 19-20. Locomotive frames, worn parts.

Long Pipe Welding Job, Canadian Manufacturer (Feb., 1925), Vol. 45, p. 34. General plan, supplies required, economics of inspection, tests of 25,000 welds.

Manganese Steel, Autogeneous Welding of. Autogene Schweissung von Manganstahl. S. W. Miller, Acetylene (Oct., 1924), Vol. 27, pp. 73-5 (Sept., 1924), pp. 67-72.

Microstructure of Arc Welded Carbon Steel, H. A. Abram, Welding Journal, London (January, 1925).

Railroad Welding, A. F. Dillon, Railway Purchases and Stores (Feb., 1925).

Resistance Welding, F. E. Saunders, Electricity (Dec. 12, 1924), Vol. 38, p. 682.

Steel Caskets Are Custom Made, H. R. Simonds, Iron Trade Review, Vol. 76 (Feb., 1925), pp. 448-51, 486.

Testing Welded Pipe Joints, Power, Vol. 61 (Feb. 10, 1925), p. 225.

Thermit Welded Crossings for Tramways, Tramway and Railway Welding (Nov. 20, 1924), Vol. 61, pp. 263-4.

Themit Welding, Cecil Leigh and Alfred Scott, Welding Journal, London (January, 1925).

Welded Pipe Installations, Power (Feb. 17, 1925), Vol. 61, p. 272.

Welding and Cutting in Railroad Shops, W. H. Ludington, Welding Engineer, Vol. 10 (Feb., 1925), pp. 32, 34, 36. Welding, cutting, pipe lines.

Welding Metal, Apparatus for. C. H. Stoody and others, U. S. Pat. 1516471, Off. Gaz. (Nov. 18, 1924), Vol. 328, p. 772.

Welding Pipe Bends in Any Form, Welding Engineer, Vol. 10 (Feb., 1925), pp. 28, 29. Repairing of City Gas Lines proves to be large item in the uses of acetylene welding.

Welding Rod Dominion Oxygen Co., Ltd., Canadian Pat. 245594, Pat. Off. Rec. (Dec. 23, 1924), Vol. 52, p. 2957.

Welding Torch, J. L. Anderson, U. S. Pat. 1516486, Off. Gaz. (Nov. 25, 1924), Vol. 328, p. 846.

Welding Torch, P. Wade, U. S. Pat. 1416655. Off. Gaz. (Nov. 25, 1924), Vol. 328, pp. 879-80.

Welding Torches, Attachment for, F. H. Simmons, U. S. Pat. 1519639, Off. Gaz. (Dec. 16, 1924), Vol. 329, p. 723.

Bound Volumes

Journal of American Welding Society

1922, 1923 and 1924

NOW ON SALE

Includes Index of Subjects and Authors

Price per Copy: Members, $5; Non-Members, $10

Volumes 1 and 2 Now Ready

American Welding Society

33 West 39th Street

New York, N. Y.

PROGRESS IN WELDING

To progress in welding you must be a reader of the Acetylene Journal—a monthly magazine, now in its 25th volume, devoted to oxy-acetylene welding and cutting.

Its articles are interesting, instructive and well illustrated. Contributed to by men of experience in all the different branches of the industry. Each issue contains information you cannot afford to be without.

A request will bring you a sample copy, which will prove that the Journal should be a part of your equipment.

Price $2.00 in the United States and Canada
Foreign $3.00.

STUART PLUMLEY, Managing Editor

ACETYLENE JOURNAL

53 WEST JACKSON BLVD. CHICAGO, ILL.

All books on gas welding may also be obtained through this office, including the famous "Autogenous Welding" by Granjon & Rosemberg (price $3.00), for which this office has the exclusive American rights.

Member Associated Business Papers, Inc.

The Welding Engineer

Member Audit Bureau of Circulations

FOUNDED BY L. B. MACKENZIE, 1916

"Take the Guess Work Out of Welding"

AN old slogan around the office of *The Welding Engineer*, but still one which cannot be emphasized too much. In your plant there is a man who needs timely, accurate and practical information about welding. See that he gets *The Welding Engineer* regularly. Subscribe now.

No matter what your welding problem may be, *The Welding Engineer* is the best source of information available. Its pages discuss, monthly, every phase of welding. One idea from one issue will more than pay for a year's subscription to this valuable publication. The value of the reading matter is assured for the best welding authorities in America are regular contributors.

Arc Welding, Electric Butt, Spot and Seam Welding, Oxy-Acetylene and the Thermit System, in fact every known process of joining metals is discussed. Our Buyers' Index reflects the progressiveness of America's first manufacturers.

Price $3.00 in the United States and Canada; $4.00 Abroad

Sample Copy Sent Free Upon Request

G. H. MACKENZIE, PUBLISHER WELLINGTON W. BROTHERS, EDITOR

The Welding Engineer—608 S. Dearborn Street, Chicago, Ill.

Todd Twin Pole Arc Welders Satisfy—

Both owners

Because they are economical in power consumption, requiring only 6 h. p. for standard work—because they are so simply designed and easily operated that very little training is necessary before an inexperienced operator can do good welding—and because they embody all the advantages of welding, operating on D. C. generator, driven by local A. C. current or gasoline engine.

and operators

Because Todd Welders are designed from the operator's standpoint to make his work easier. These welders maintain a short arc, which is easy to handle, so that heat is concentrated to prevent the uncomfortable "blowing over", provide deeper penetration and faster melting of the metal to make the work quicker.

Todd Twin Pole Arc Welders are manufactured in ten different types, including stationary and portable units. Those equipped for gasoline drive are most practicable for field work as power is available not only for welding but for operating drills, grinders, chippers, caulking tools and lights.

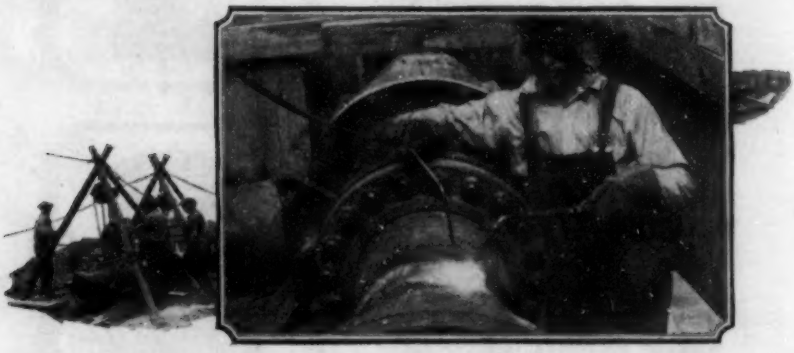
Todd Twin Pole Arc Welders
25 Broadway New York City

TODDWELD
the electrode that insures perfect and tough welds, is part of our complete line of welding accessories. Send for a sample bundle of TODDWELD.

TODD
NEW YORK, U.S.A.

Southern Distributor
C. T. Patterson Co., Ltd.
800 South Peters Street
New Orleans, La.

Cleveland's *Remarkable* Welding Job



6,000 *Feet of 16-inch High Pressure Steam Line*

PAGE ARMCO WELDING RODS, used to weld 6,000 ft. of 16" steel pipe, ½" thick, pressure steam line of the Cleveland Electric Illuminating Company, Cleveland.

EACH Welded joint has to stand 500 lbs. test. Five pounds of added metal is applied to each joint.

The welding men naturally chose Page-Armco, the most uniform, easiest flowing, gas-free rods on the market. It saved time—gave them a better job.

Rods are a small part of welding cost. Can you *ever* afford to take chances—use any but the best? Try PAGE-ARMCO, time the job, and inspect it and test it.

PAGE also makes high carbon rods —rods of all types for gas, electric and automatic welding. Write for illustrated folder telling how better rods cut welding costs. No obligation. A card will do.

PAGE STEEL & WIRE CO.

Bridgeport, Connecticut

District Offices, Chicago, New York, Pittsburgh, San Francisco

An Associate Company of American Chain Co., Inc., of Bridgeport

ARMCO ingot iron

PAGE

WELDING RODS

Announcing
The New Wilson Type S Welding Machine

IN producing the New Type S Welding Machine, the Wilson company has advanced still further its leadership in the building of welding machines. Control of current fluctuations, which assures *constant* heat at the weld, is brought to its highest, and well-nigh perfect, point of efficiency in the New Wilson Type S. This control, combined with the ease with which the arc is *struck* and *held*, makes flawless welding the usual result with the Wilson Type S. Its sturdy construction and simplified panel reduces maintenance cost and lowers the cost of welding. Gasoline-engine-driven and electric-motor-driven — each a complete, self-contained unit. Send for descriptive literature.

WILSON WELDER & METALS CO. INC.
Wilson Bldg. Hoboken, N. J.

Canadian Distributors: G. D. Peters & Co., Ltd., Montreal

WILSON

WELDING MACHINES AND WELDING WIRE

Swedox

The World's Best

Welding Rods

and

Electrodes

A GRADE FOR EVERY PURPOSE

NON-OX SWEDOX	CYLKOTE	ALUMINOX	BRONZKOTE
LEKTROX SWEDOX	MANKOTE	DRAWN ALUMINUM	MONEL METAL
CASTOX	RAILKOTE	BRAZOX	TENSILOX
ARC CARBOX	TENSKOTE	BRONZOX	KROMKOTE
GAS CARBOX	NICKOX	TOBIN BRONZE	NICKOTE
VANOX	RAILOX	MANGANESE BRONZE	VANKOTE
STEELKOTE	KROMOX	DUCTKOTE	
LEKKOTE	MANGANOX	DUCTILOX	

FLUXES

The above list of Welding Rods conforms to the American Welding Society's specifications E No. 1A, E-No. 1B, E-No. 1C, G No. 1A—Follos Nos. 1-E and 1-G, and a large variety of other analyses developed by us for special purposes.

A large stock of all sizes of the above classes of material is carried in both our Chicago and Detroit warehouses. Send for our stock list and other descriptive matter covering our SWEDOX line.

Put your welding problems up to our experts. (Demonstrations will be made wherever possible.)

Look for the SWEDOX TAG. It is your protection.

Chicago Office and Warehouse
4545 S. Western Blvd.
CHICAGO, ILL.
Phone Lafayette 8500

Central Steel & Wire Company

Detroit Office and Warehouse
5001 Bellevue Ave.
DETROIT, MICH.
Phone Lincoln 6780

FREE SAMPLES OF ANY ROD SENT UPON REQUEST

MILBURN

Efficiency and economy of gases are achieved in Milburn Welding and Cutting Apparatus.

Welding Torches	Acetylene Generators	Regulators
Cutting Torches	Compressing Plants	Accessories

Send for Catalog No. 354

THE ALEXANDER MILBURN COMPANY

1416-28 W. Baltimore Street Baltimore, Md.

K-G Welding & Cutting Co., Inc.

556 WEST 34th STREET

NEW YORK CITY

MANUFACTURERS OF

K-G-TORCHES

ACETYLENE IN PORTABLE CYLINDERS FOR OXY-ACETYLENE WELDING AND CUTTING

Do you understand our free loan cylinder plan? If not, we are glad to explain

Supplied in the following size cylinders:

10" x 30"—capacity 125 cu. ft.
12" x 36"— " 225 " "
12" x 44"— " 275 " "

Prompt and efficient service on any quantity through plants and warehouses and truck deliveries.

Commercial Acetylene Supply Co., Inc.
(Main Office) 80 Broadway, New York City, N. Y.

BRANCHES:
421 Trust Co. of Georgia Bldg., Atlanta, Ga.
80 E. Jackson Boulevard, Chicago, Ill.
553 Monadnock Bldg., San Francisco, Cal.

Essentials for Safe and Reliable Electric Arc Welding

WANAMAKER COATED ELECTRODES and TECOR ACCESSORIES

Write for Booklet

TRANSPORTATION ENGINEERING CORPORATION
909 EAST 134TH STREET, NEW YORK
327 S. LA SALLE STREET, CHICAGO

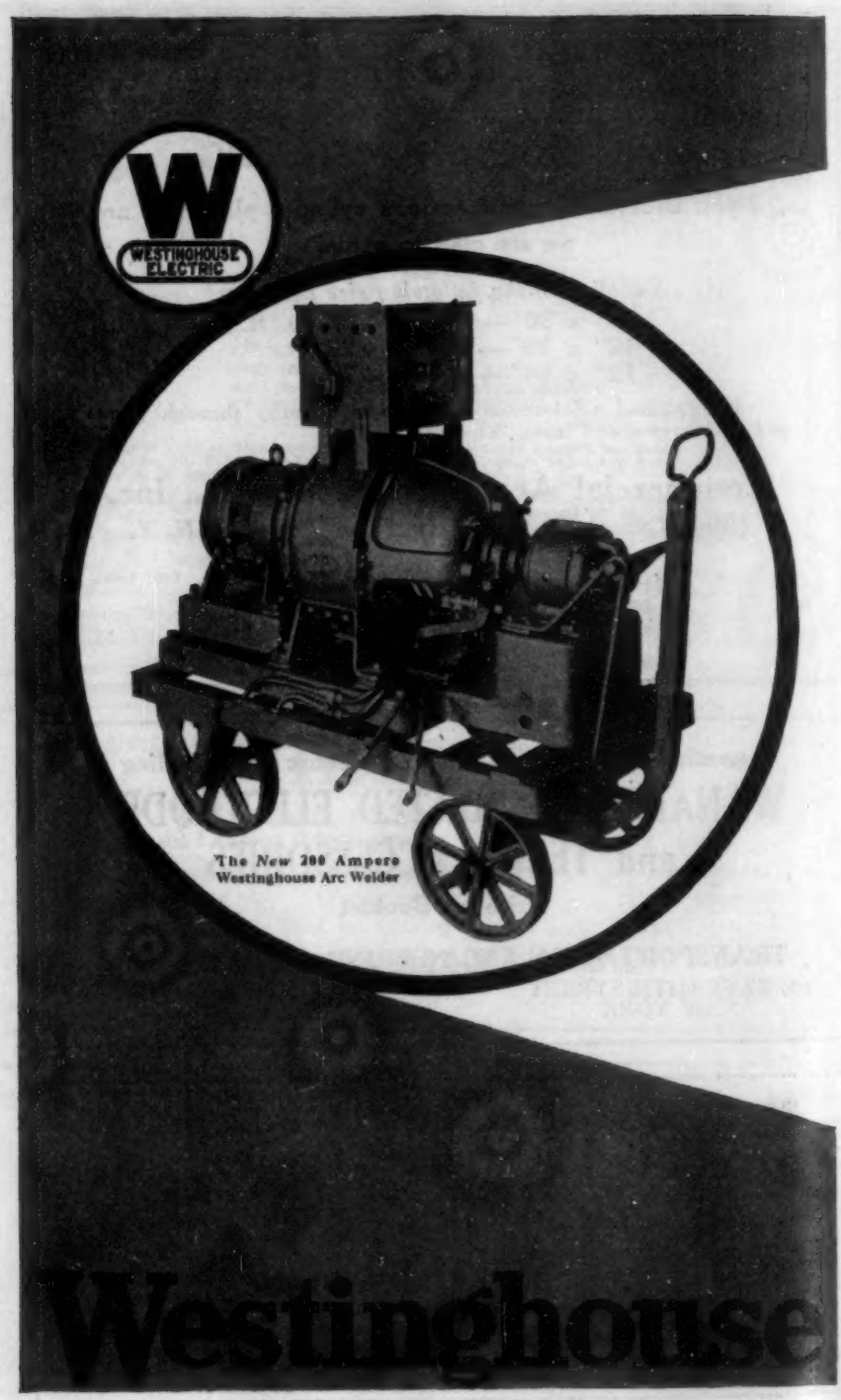
BUILT UP TO A STANDARD NOT DOWN TO A PRICE

Torchweld Gas Welding and Cutting Equipment represents the highest development in its line.

Every need of the Gas Welding and Cutting Industry is covered by the Torchweld Line of Apparatus, Accessories and Supplies.

Send for Catalog No. 23-A

TORCHWELD EQUIPMENT COMPANY
224 No. Carpenter St. Chicago, Ill.


W
WESTINGHOUSE ELECTRIC
The New 200 Ampere
Westinghouse Arc Welder
Westinghouse

Solid Facts
about Welding

FOR simplicity of operation, good fusion and a perfect weld, the Westinghouse Arc welder is absolute assurance of complete satisfaction.

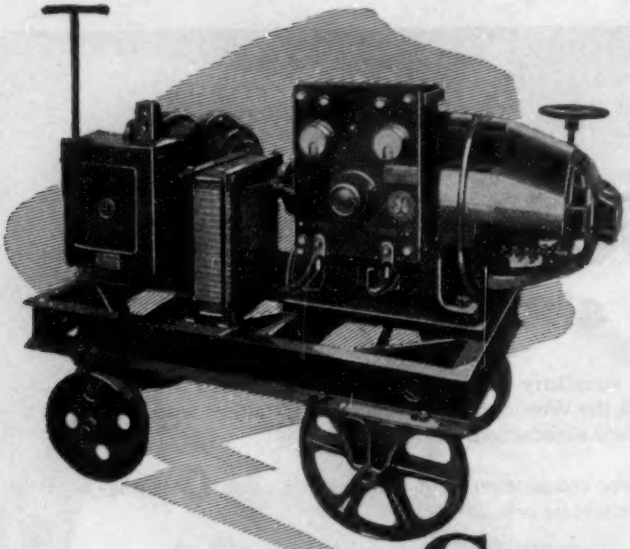
The salient characteristics of the new 200 ampere Westinghouse arc welder are:

1. One operation only for complete current adjustment.
2. A current range from 60 to 300 amperes in 61 steps with one current setting of the rheostat.
3. Handles all commercial sizes of electrodes from one-sixteenth inch to one-fourth inch inclusive.
4. Ease of striking and maintaining arc due to the quick recovery of arc voltage from the generator.
5. A definite rating of 200 amperes at 25 volts for one hour when operating on a constant resistance load—with a temperature rise not exceeding 50° Centigrade.
6. Can change from downward welding to overhead without changing current.

The test of actual experience has proved the new Westinghouse arc welder able to withstand the most severe welding operation. This new equipment is fully explained in our publication—Arc Welding and Cutting. Send for a copy.

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

Arc Welders



Speed!

—a feature of the WD-12 ARC WELDER

The WD-12 Arc Welder

—can be furnished for any commercial voltage, phase or frequency.

—delivers 200 amperes continuously and 300 amperes for short periods.

—voltage can be adjusted to suit work.

—a two-unit machine (motor and generator).

—generator is self-excited.

—reactor automatically steadies arc.

—hand-wheel on generator for regulating welding current.

—any value of welding current between 75 and 300 amperes.

—supplies power to G-E Automatic Arc Welder for continuous welding.

Speed—because this welder operates on heavy currents and with all commercial sizes of electrodes up to ¼" in diameter.

Speed—through smooth and rapid deposition of metal with thorough penetration.

This increases the metal deposited per hour—and the footage per day.

Ready to work when delivered.

There is a suitable G-E welder for your every arc welding need. Ask the nearest G-E sales office for complete information.

General Electric Company
Schenectady, N. Y.
Sales Offices in all Large Cities

28A-1D

GENERAL ELECTRIC

The highest of purity standards is but one of the many advantages enjoyed by users of

Prest-O-Lite

DISSOLVED ACETYLENE

THE PREST-O-LITE COMPANY, INC.

Oxy-Acetylene Division

General Offices: Carbide & Carbon Bldg., 30 East 42d St., New York
In Canada: Prest-O-Lite Co. of Canada, Limited, Toronto

31 Plants—55 Warehouses—21 District Sales Offices

Why will you find our man in your plant?

WELDING SHOPS know what Oxweld utility men can do. One service report says: "In order not to interrupt production I installed their new Oxweld 100 lb. Duplex Generator on Saturday afternoon and Sunday. During the same period I also overhauled eight oxygen regulators and a number of welding heads, and otherwise did everything necessary to assure their installation being in first class order."

THE PURCHASE of Oxweld apparatus does not end with the delivery of the apparatus to you.

The Oxweld Acetylene Company considers it a part of its duty to help keep all Oxweld apparatus in proper condition and working efficiently.

It is also a part of Oxweld's duty to see that all Oxweld customers are informed of the best methods of welding and cutting, and that they are instructed in new processes discovered by the research laboratories.

The greater part of this obligation can be fulfilled only by personal visits to your plant. That is why some day you will find an Oxweld utility man in your plant.

He will be inspecting your apparatus, making minor repairs or adjustments, instructing or informing your operators on new methods, doing everything he can to help you obtain the fullest use of your Oxweld apparatus.

Oxweld Acetylene Company

LONG ISLAND CITY, N.Y.
Thompson Ave. & Orton St.

CHICAGO
3642 Jasper Pl.

SAN FRANCISCO
1050 Mission St.

Oxweld

WELDING AND CUTTING APPARATUS

World's Largest Manufacturers of Cutting and Welding Equipment

LINCOLN ARC WELDER

EASE OF OPERATION

This is the one important thing which a buyer of arc welding equipment should consider.

If the machine is easy to operate that is a certain indication that its electrical design is right. It is further a guarantee that it will work rapidly and make good sound welds. Easy operation always makes for speedy welding and good welding.

Branch Offices
Baltimore
Boston
Buffalo
Charlotte, N. C.
Chicago
Cincinnati
Detroit
Des Moines
Grand Rapids

The Lincoln Electric Co.

General Offices and Factory:
Cleveland, Ohio

The Lincoln Electric Co. of Canada, Ltd., Toronto-Montreal
European Representatives: Allen-Liversidge, Ltd., London

Branch Offices
Indianapolis
Milwaukee
Minneapolis
New York City
Philadelphia
Pittsburgh
Rochester
St. Louis

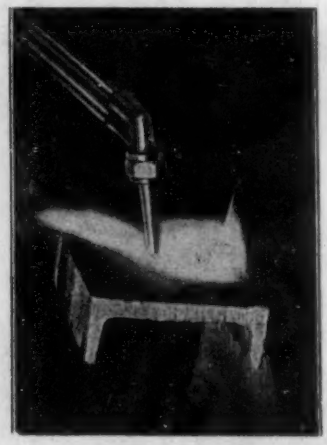
Distributing agencies in all principal cities.

Exclusive Agencies with Stock:
Ft. Worth, Texas
New Orleans
Los Angeles
San Francisco

REGO REGO REGO REGO REGO

REGO

One Piece Pure Copper Tips Stands the Gaff



Satisfy yourself. Take a REGO one piece pure copper tip and run a test against a tip of any other construction or material. The REGO tip will stand up longer, under hotter conditions because:

Pure copper radiates heat—doesn't hold it—better than any other metal or alloy.

One piece construction eliminates easily burnt out brass terminals.

Write for No. 32 Pocket Catalog descriptive of the entire REGO line of welding and cutting equipment

REGO IS DISTRIBUTED NATIONALLY BY

Kentucky Oxygen Hydrogen Co.,	Logan St. & Goss Ave.,	Louisville, Ky.
Weldex Equipment Co.,	350 West 52nd St.,	New York City.
International Oxygen Co.,	796 Frelinghuysen Ave.,	Newark, N. J.
Gas Products Co.,		Columbus, Ohio.
Memphis Oxygen Co.,	48 W. McLemore Ave.	Memphis, Tenn.
Mountaineer Welders' Supply Co.,	408 So. Main St.	Butte, Mont.
St. Paul Welding & Mfg. Co.,	174 W. Third St.,	St. Paul, Minn.
The Bastian-Blessing Co.,	252 East Ontario St.	Chicago, Ill.

REGO REGO REGO REGO REGO

ACETYLENE FROM CAKES

Carbic low pressure, portable generator. Weight charged—200 lbs.

Listed as standard by Fire Underwriters' Laboratories.

The most modern, efficient and safest source of acetylene supply—Carbic CAKES.

Not an experiment. Hundreds of Carbic generators using Carbic are in daily use on all kinds of welding and cutting work.

The use of Carbic Cakes permits an ease of handling, a convenience and a safety not otherwise obtainable.

Acetylene from Carbic costs less than one-half as much as compressed acetylene and only a few drums of cakes carried in stock insure a large supply of gas on hand at all times.

THE Carbic SYSTEM

CARBIC MFG. CO.

Duluth, Minn. New York, 141-149 Centre St.
Boston, 27 School Street Chicago, 565 W. Wash. Blvd.
The Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colorado.
Woodward, Wright & Company, New Orleans, La.

Offices and Representatives in other principal Cities

ROEBLING WELDING WIRE

High Carbon Electrodes
Low Carbon Electrodes
Gas Welding Wire

Conforms to specifications of The American Welding Society

Exacting tests have proven that it possesses those qualities essential to good welding.

John A. Roebling's Sons Company
TRENTON, NEW JERSEY

WELDING BOOKS

The Society has made arrangements for the distribution and sale to its members of the following books on welding:

Fundamentals of Welding Gas, Arc and Thermit. James W. Owens. $10.00.
Arc Welding Handbook. C. J. Holslag. $2.00.
Oxy-Acetylene Welding and Cutting. P. F. Willis. $1.50.
Automobile Welding with the Oxy-Acetylene Flame. M. Keith Dunham. $1.50.
Modern Welding Methods. Vincent W. Page. $3.00.
Welding Encyclopedia. $3.00.

THERMIT WELDING

For heavy welding operations in all fields

Railroad Industrial Marine

METAL & THERMIT CORPORATION

120 Broadway, New York

Pittsburgh Chicago Boston S. San Francisco Toronto

ARC WELDING HAND BOOK by C. J. HOLSLAG.

Published by McGraw-Hill Book Co.

Describing fully the ART OF ELECTRIC ARC WELDING.

Send coupon by return mail.

Electric Arc Cutting & Welding Co.
153-156 Jelliff Ave., Newark, N. J.

PRICE $2.00

Send me on approval "Arc Welding Hand Book." It is understood that I am to have the privilege of returning within five days if not satisfied.

Name ..... Address .....

Position ..... Firm .....

"All Regulation of Current Is Accomplished by Turning a Hand-Wheel on the Generator"

This feature was originated by us and has been embodied in our Arc Welding Machines for over three years.

Dependable Welds Require Dependable Equipment

Under the most severe service conditions these machines have demonstrated their mechanical and electrical fitness.

Let us send you more complete information.

BURKE ELECTRIC COMPANY

ERIE, PA.

Service-Sales Offices:

Buffalo, Cleveland, New York, Pittsburgh, Chicago, Detroit, Philadelphia

Sales Agencies:

Cincinnati — Underwood Electric Co.

Kansas City — W. T. Osborn

Chicago — Western Welding & Equipment Co.

Milwaukee — Fred H. Dorner

The Purest Oxygen

Is Always the Most Economical

Airco Oxygen Is 99.5% Pure in the Cylinder

Buy Your Oxygen on this
Specification for Purity

AIRCO
DAVIS
BOURNONVILLE

AIR REDUCTION SALES CO.

Manufacturer of Airco Oxygen, Acetylene and Calorene
Airco-Davis-Bournonville Equipment and Supplies
Controls the Manufacture and Sale of National Carbide

Home Office: 342 Madison Avenue, New York City

26 Airco Oxygen Plants 13 Airco Acetylene Plants 2 Airco Calorene Plants
16 Airco District Offices 14 Airco Repair Stations 82 Airco Distributing Points

Airco Apparatus Factories and Laboratories at Jersey City and Elizabethport, N. J.

Anything and Everything for Oxyacetylene Welding and Cutting

Copyright 1925, Air Reduction Sales Co.